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SCIENCE ABSTRACTS

SECTION A.—PHYSICS.

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1921

NAME INDEX.

Abbott, R. B., 466.
Adams, E. Q., 465.
Alemany, J., 573.
Andrade, J., 341.
Arakatsu, B., 356.
Aston, F. W., 364, 447.
Bachem, A., 380.
Baldwin, J. M., 343.
Banerji, B. N., 491.
Barton, E. H., 494.
Basu, S. N., 432.
Bauer, E., 534.
Bavendick, F. J., 371.
Baxandall, F. E., 398.
Beckenkamp, J., 541.
Belot, E., 385.
Bergdahl, B., 568.
Berndt, G., 420, 463, 476.
Blake, F. C., 524.
Bloch, E., 439, 442.
Bloch, L., 439, 442.
Block, W., 370.
Bohr, N., 445.
du Bois-Reymond, A., 489.
Bowen, E. J., 540.
Brazier, C. E., 375.
Breit, G., 516, 517.
Bridgman, P. W., 523.
de Broglie, L., 462.
Browning, G., 378.
Browning, H. M., 494.
Buchner, E. H., 556.
Bull, A., 572.
Busch, H., 526.
Cabannes, J., 415.
Cabrera, B., 574.
Chadwick, J., 366.
Chauvierre, M., 560.
Chree, C., 357.
Claude, 407.
Clayton, H. H, 367.
Compton, A. H., 535.
Compton, K. T., 501.
Cook, J. W., 488.
Crookes, B. H., 360.
Dadourian, H. M., 458.
Danjon, A., 386, 387, 397.
Datta, B., 499.
Davis, A. H., 478.
Deisch, N., 423.
Dember, H., 506.
Devaud, A., 533.
Dingler, H., 350.
Dodwell, G. F., 345.
Dorno, C., 369.
Downey, K. M., 466.
Driencourt, 407.
Dunne, W., 452, 457, 459.
Edwards, D. L., 404.
Ehrenhaft, F., 498.
Ewald, P. P., 454.
Ewest, H., 521.
Foley, A. L., 58.
Foisythe, W. E., 479.
Fournier, F. E., 352.
Fricke, H., 457.
Frivold, O. E., 346.
Fuchs, P., 559.
Füchtbauer, C., 444, 446.
Fukuda, M., 356, 436, 437.
Furner, H. H., 400.
Fürth, R., 355, 507.
Gehlhoff, G., 431.
Gehrts, A., 338.
Ghosh, P. N., 413.
Ghosh, R. N., 492.
Gibson, K. S., 411, 418.
Goudriaan, F., 575.
de Gramont, A., 438.
Gray, J. A., 467.
Grebe, L., 380, 381.
Gregg, W. R., 371.
Gross, R., 542, 543.
Grotrian, W., 435.
Grüneisen, E., 493.
Gudden, B., 449, 450, 502.
Günther, P., 482.
Gutbier, A., 570, 571.
Guye, P. A., 557.
Hackspill, L., 486.
Hahn, O., 472.
Hallwachs, W., 503.
Hamy, M., 403.
Hansson, A., 404.
Hartung, E. J., 484.
Hebb, T. C., 508.
Henroteau, F., 393, 394.
Hertz, G., 453.
Herz, W., 487.
Herszfinkiel, H., 470, 471.
Hettner, G., 440.
Heuck, W., 448.
Higson, G. I., 422.
Hinshelwood, C. N., 540.
Hirayama, K., 390.
Hnatek, A., 401.
Hoeltzenbein, S[ophie], 427.
v. Hofe, C., 408.
Holborn, L., 481.
Honigschmid, O., 548.
Hort, W., 342, 363.
Howe, G. W. O., 529.
Hoyt, F. C., 461.
Huber, P. B., 372.
Hudson, C. J., 391.
Hulburt, E. O., 517.
Jackson, J., 400.
Jakob, M., 477.
Jänecke, E., 552.
Jankowsky, W., 499.
Jeans, J. H., 379.
Jelstrup, H., 404.
Jones, L. A., 423.
Joos, G., 444.
Kara-Michailova, [Miss] E., 513.
Kimura, M., 436, 437, 512.
Klemenstewicz, Z., 483.
Kolhörster, W., 469.
Kossel, W., 561.
Kudara, K., 392.
Küstner, H., 560.
van Laar, J. J., 558.
Labrouste, H., 354.
Lacombe, A. E., 556.
Ladenburg, R., 351.
Landé, A., 362.
v. Laue, M., 419.
Lecornu, L., 361.
Lenz, W., 443.
Lepape, A., 376, 475.
Liesegang, F. P., 358.
Lindman, K. F., 518.
Lintow, K., 340.
Lockyer, W. J. S., 404.
Lodge, O. J., 357.
Loisel, P., 474.
Lorenz, R., 546.
Lumière, L., 409.
Luyten, W. J., 405.
McAulay, A. L., 464.
McNicholas, H. J., 413, 418.
Madelung, E., 362.
Maisch, O., 571.
Margoulis, W., 350.
Marvin, C. F., 368.
Mathieu, 486.
Menard, P., 336.
Mercanton, P. L., 339, 374.
Merkel, F., 4 9.
Mewes, R., 487.
Michailova, Kara-, [Miss] E., 513.
Mie, G., 497.
Mitra, S. K., 414.
Moore, W. A., 378.
Mourcu, C., 376.
Nolan, J. J., 473.
Obata, J., 527, 528.
Oguro, S., 393.
Ostwald, W., 555.
Ottenstein, B[erta], 570.
Owen, E. A., 530.
Paal, C., 554.
Parenty, H., 349.
Paschen, F., 434.
Patterson, R. A., 452, 459.
Pauli, W., Jr., 532.
Pérard, A., 416.
Piccard, A., 533, 534.
Piña, S., 574.
Pohl, R., 449, 450, 502, 506.
Prescott, J., 347.
Priest, I. G., 417, 418.
Procopiu, S., 421.
Przibram, K., 513.
Quennessen, L., 551.
Raman, C. V., 490.
Rambaut, A. A., 406.
Rao, K. S., 539.
Ratner, S., 511.
Ray, B., 480.
Reboul, G., 520.
Reis, A., 430.
Reymond, du Bois-, A., 489.
Ribaud, G., 410.
Riegger, H., 336.
de la Roche, B., 426.
Rognley, O., 535.
Rohmann, H., 525.
Ruff, O., 568.
Saha, M. N., 384.
Salpeter, J., 424.
Sampson, R. A., 344.
Sauzin, M., 521.
Scherrer, P., 545.
Schlesinger, F., 391.
Schmidt, K. W., 565.
Schmitz, F., 553.
Schottky, W., 509.
Seeliger, R., 340, 441.
Siemssen, J. A., 428.
de Sitter, W., 382.
Skaupy, F., 514, 529.
Slade, R. E., 422.
Slipher, V. M., 388.
Smith, J. W., 368.
Sommerfeld, A., 365, 433.
Stenström, W., 457.
Steyer, H., 554.
Taylor, A. H., 412.
Theodoridès, P., 537, 538.
Thorkelsson, T., 495.
v. Traubenberg, H., 468.
Tuczek, F., 448.
Turner, H. H., 402.
Tyndall, E. P. T., 411.
Tammann, G., 562, 563, 564, 565, 566, 567, 569.
Tendt, H., 544.
Trautz, M., 549.
Ueta, Y., 524.
Vaillant, P., 451, 519.
Venkatasubbaraman, A., 348.
Véronnet A., 396.
Vogel, R., 560.
Wagner, E., 456.
Walter, B., 504.
v. Wartenberg, H., 547.
Watanabe, N., 531.
Weaver, W., 536.
Weidert, F., 430, 476.
Weigert, F., 425.
Weise, G. L., 570.
Wertenstein, L., 470, 471.
Wessely, K., 363.
Weyl, H., 496.
Witzel, G., 547.
Wolff, W., 460.
Woolard, E. W., 373.
Yamamoto, I., 392, 399.
Young, R. K., 389.
Zahm, A. F., 337.

SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MARCH 1921.

GENERAL PHYSICS.

335. *Mercury Manometer.* **P. Menard.** (Comptes Rendus, 171. pp. 1129–1130, Dec. 6, 1920.)—The manometer described is of U-form, one limb being much longer than the other. The end of each limb opens into a bulb, into the top of which is sealed a tube of small diameter shaped like a buttonhook. The end of this tube is at such a distance from the top that if the manometer is inverted and the whole of the mercury run into either limb, the mercury level would not quite reach the end of the tube. Hence, if by accident the manometer is inverted, there is no danger of the loss of any mercury. The partial closing of the tops of the manometer limbs causes the motion of the mercury to be damped, since the air above the mercury can only escape slowly through the narrow orifice. A. W.

336. *Vacuum Manometer; New Type of Apparatus.* **H. Riegger.** (Zeits. techn. Physik, 1. 1. pp. 16–19, 1920.)—Gives a short account of the methods hitherto employed for the measurement of very low pressures. The new instrument described consists of a suspended system made from an Al disc slit radially into a large number of sectors, each sector being then bent so as to make an angle of 45° with the original plane of the disc. This many-bladed "propeller" is suspended by a fine tungsten thread so that its blades lie vertically beneath an annular plate, which is heated electrically. The impact of the molecules heated by the plate causes the "propeller" to rotate through a given angle, which is measured by means of a circular scale attached to it. Curves are given to show the proportionality of torsion to pressure for pressures up to 10^{-3} mm. Hg. The effect of the nature of the gas is also shown. J. W. T. W.

337. *Cross-arm Wind Balance* **A. F. Zahm.** (Frank. Inst., J. 190. pp. 685–690, Nov., 1920.)—A full description, with illustrations, of an aerodynamic balance capable of measuring lift, drag, and pitching moment simultaneously. J. W. T. W.

338. *Pumps for High Vacua.* **A. Gehrts.** (Zeits. techn. Physik, 1. 3. pp. 61–71, 1920.)—According to Langmuir a high vacuum is defined as one in which the residual gases and vapours are no longer discernible

by compensation methods. Taking the case where an electronic stream is passing from a glowing kathode to anode, the field produced by this stream exerts a reverse effect whereby a definite additional potential gradient dependent on the current strength is required in order to promote the electronic emission to the anode. Before the state of saturation is attained, Langmuir and Schottky's law holds, namely, $i = \text{const. } V^{3/2}$, that is, the current is proportional to the 3/2 power of the potential. If residual gases are present to an appreciable extent in the evacuated space, the number of positive ions formed by impact ionisation is increased, and the Langmuir-Schottky law ceases to be valid. From this standpoint a very complete discussion of the general characteristics of high-vacuum pumps is given, accompanied by diagrams. Curves are included, showing the suction velocity as a function of the pressure, and also of the mercury temperature. Among the designs which receive special attention are Gaede's diffusion air-pump. the parallel jet pump of Crawford, and the condensation pumps of Langmuir, Gaede, and Siemens and Halske. A theoretical discussion of suction velocity concludes the paper.

H. H. Ho.

339. *Simple Maximum Anemometer.* **P. L. Mercanton.** (Archives des Sciences, 2. pp. 511–513, Nov.–Dec., 1920. Paper read before the Soc. Suisse de Géophysique.)—It is often desirable to have instrumental evidence as to the max. force attained by the wind during a gale, and for this purpose a simple, inexpensive maximum anemometer would be useful. The principle of the Pitot tube suggests itself. Three forms of the instrument have been designed. The first two necessitate the employment of a Dines vane communicating with a manometer. In the first this consists of a U-tube containing oil. The difference between the static and dynamic pressure of the air displaces the oil in the tube, and the farthest point reached is marked by a glass index acting like that in a minimum thermometer. In the second form a metallic Bourdon-Richard manometer is used, recording by a light pivoted index. The third instrument is cheaper, but less accurate. It consists of a glass reservoir with two tubes leading out of it, one vertically and the other obliquely, and at the top each tube has a short horizontal extension, in the plane of the two tubes. The whole is mounted on a vertical pivot and swings with the wind, so that the horizontal extension from the vertical tube faces the wind. The reservoir contains oil, which also enters the lower part of the oblique tube. During wind the oil is consequently forced up the latter, which has at intervals small pockets. These retain small drops of oil when the main body recedes, and the highest pocket so filled marks the approximate height to which the oil ascended, and hence gives an approximate measure of the force attained by the wind. [The diagram illustrating the instrument appears to be printed upside down.]

M. A. G.

340. *Measurement of Rapidly Fluctuating Velocities in Gas Streams.* **R. Seeliger** and **K. Lintow.** (Zeits. techn. Physik, 1. 1. pp. 20–27, 1920.)—Describes apparatus which, consisting of Pitot tubes attached to a pneumatic box, responds very quickly to fluctuations of velocity in the gas stream, and gives records of these fluctuations. The effect of the length of tube from outlet to manometer is discussed in the paper.

J. W. T. W.

341. *Ultimate Perturbations of Isochronism.* **J. Andrade.** (Comptes Rendus, 171. pp. 995–997, Nov. 22, 1920.)—Treats the perturbations of the balance wheel of a chronometer owing to (1) the variable inertia of the hair spring, and (2) the variable friction. It is shown that the second perturbation is negligible, so that the whole disturbance reduces to that due to the first alone. E. H. B.

342. *Approximate Solutions of the Differential Equation for Oscillations.* **W. Hort.** (Zeits. techn. Physik, 1. 9. pp. 182–189, 1920.)—A description is given of three graphical methods by which an approximate solution can be obtained of equations of the type $P_0 d^2x/dt^2 + P_1 dx/dt + P_2 = f(t)$. The first method makes use of the circle of curvature, the second of integral curves, and the third of a system of two first-order simultaneous differential equations. A. W.

343. *Correction for Chronometer Rate.* **J. M. Baldwin.** (Roy. Soc. Victoria, Proc. 32. p. 147, Sept., 1920.)—The following easy way of applying the correction for chronometer rate has been in use at the Melbourne Observatory for some years. Let T be the period of a vibrating system in seconds, T′ the period as shown by a chronometer, r the daily rate of the chronometer, positive if losing, then it is easy to show that $T = \log T' + 0{\cdot}43429\{r/86400 + \frac{1}{2}(r/86400)^2 + \ldots\}$. The value of the right-hand side is nearly $\log T' + r/2 \times 10^{-5}$, so that to obtain log T it is only necessary to add half the daily rate in seconds to the fifth decimal place of log T′. The value of T so obtained will be within one part in 10^6 for values of r up to 15 seconds. If a sidereal chronometer is used, $r = -236{\cdot}56$, and even in this case the accuracy attained is 1 part in 10^5. The expression $\log T = \log T' + r/2 \times 10^{-5} + r/380 \times 10^{-5}$ gives a value of T correct to 1 part in 10^6, provided r is not greater than 120, while the addition of the extra term $+ (r/900) \cdot (r/380) \times 10^{-5}$ gives more than sufficient accuracy in every case. A. W.

344. *Clock Errors and Wireless Time-Signals.* **R. A. Sampson.** (Roy. Astron. Soc., M.N. 81. pp. 89–100, Nov., 1920.)—The author has been investigating the accuracy of wireless longitudes [see Abs. 1221 (1920)], and here tabulates first sources of clock error, as follows:

(*a*) Actual fluctuations of rate in the clock whether transitory or long continued, slow, rapid, or instantaneous.
(*b*) Faults of the chronographic system by which the record of the clock or the record of the observation is made with a lag, which varies from one observation to another.
(*c*) Errors in determination of instrumental corrections of transit circle.
(*d*) Errors due to catalogue places of stars observed.
(*e*) Anomalies, if any, due to atmospheric causes.
(*f*) Accidental error of observing.
(*g*) Personality of observers.

Of these he considers the first and last. The clock rates, he thinks it best to assume, do not change gradually, but are best represented by a series of straight lines and not by a curve. From 1915 Jan. to 1920 Oct. he tabulates the base rates and erratics of the standard clock of the Edinburgh Observatory, divided into homogeneous series, broken off

whenever anything occurred to alter the adjustments, with an account of the method of adopting the base rate.

The personal equation considered is that of the Paris wireless comparisons, and includes :

(*a*) Error in reputed relative longitude of Paris and Edinburgh.
(*b*) Errors in reputed time at Paris.
(*c*) Errors in reputed time at Edinburgh.

Into the observations at Edinburgh is introduced the lag of a slave clock, driven by the standard clock, but in this there seems to be absolute agreement between different observers, so no personality is to be allowed. An extract is given from the table of comparisons, Paris and Edinburgh, and a summary of the results for the whole period from 1914 March to 1920 Oct.

Conclusion.—The conclusion is that the clock errors at a single observatory are less accordant from day to day than would be expected from the individual observations, and the differences between two observatories will be still greater. W. W. B.

345. *Adelaide Longitude by Wireless.* **G. F. Dodwell.** (Roy. Astron. Soc., M.N. 81. p. 101, Nov., 1920.)—Rhythmic signals from Lyons were received at Adelaide from June 23 to July 5, 1920. Comparing the recorded times with those at Greenwich, and allowing 0·04 sec. for time of transmission, the Adelaide longitude comes out 9h. 14m. 19·95s., to compare with adopted value 9h. 14m. 20·07s.

Indirect determinations by means of series of Annapolis signals in July and Aug. gave 9h. 14m. 19·79s. and 9h. 14m. 19·78s. respectively, but these have not the same weight as the Lyons signals, as the Annapolis signals received at Greenwich are those sent at 17h. G.C.T., while those received at Adelaide are sent at 3h. G.C.T. W. W. B.

346. *Determining the Density of Liquids : Water Saturated with Air.* **O. E. Frivold.** (Phys. Zeits. 21. pp. 529-534, Oct. 15, 1920.)—The author modifies the apparatus used by Piccard and Cherbuliez [Abs. 245 (1916)] for determining the magnetic susceptibility of copper salts in very diluted solutions. Their apparatus consists of two vertical tubes, communicating at the top and bottom by horizontal connections provided with taps. When the two tubes contain liquids of different densities, circulation will start on opening the upper tap ; this circulation, observed in the Piccard micromanometer, is prevented by setting up a pressure on the one column with the aid of a magnetic field ; the measurements then become electrical. The author reduces the height of the apparatus from 8 m. to 2 m. The main difficulties are the thermal insulation of the apparatus, especially to prevent slight temperature differences between parts of the two columns at the same level, and a pumping effect arising when the tap-bores are not truly central. Filling the one tube with distilled water free of air, and the other with the water saturated with air, he finds a density difference of $19{\cdot}02 \times 10^{-7}$ at 15·6°, which agrees with Marck's value 20×10^{-7} (1891) ; the only other determinations by Chappuis (1910, float and pycnometer methods) gave less concordant results. H. B.

347. *Torsion of Closed and Open Tubes.* **J. Prescott.** (Phil. Mag. 40. pp. 521-541, Nov., 1920.)—Deduces, from St. Venant's theory of

torsion, approximate formulæ for the torsion of closed tubes, and of rods whose sections are long thin strips, such, for example, as split tubes. Although the results are only approximate, the percentage errors they contain approach zero as the ratio of the length to the breadth of the section approaches infinity. For example, in the case of a circular tube, whose inner and outer radii are $(r - \frac{1}{2}t)$ and $(r + \frac{1}{2}t)$, the proportional error in the result is $t^2/4r^2$. The approximate results obtained for closed tubes fail altogether with unclosed or split tubes. In this case it is shown that wherever the shear lines are nearly parallel, either in a thin straight strip, or in a thin curved strip where the width is small compared with the radius of curvature, the shear stress is approximately proportional to the distance from the middle line of the strip, and is in contrary directions on the two sides of the middle line. A formula is for the case of a uniform circular tube split longitudinally.

J. W. T. W.

348. *Experiments on Impact.* **A. Venkatasubbaraman.** (Indian Assoc. for Cultivation of Science, Proc. 6. 1 and 2. pp. 109-112, 1920.)—C. V. Raman has shown how the well-known theory of impact developed mathematically by Hertz may be extended and applied to the problem of the transverse impact of a sphere on a plane elastic plate of finite thickness. To test the formula thus obtained, the author of this paper has made a series of observations, using a set of polished hard steel balls of various diameters and a set of glass plates of different thicknesses. Within certain limits the observed values of the coefficient of restitution and those calculated by Raman's formula show very good agreement. The diameters of the spheres used ranged from 0·237 to 0·791 cm., the thicknesses of the glass plates from 0·105 to 2·53 cm., the speed of impact being 234 cm. per sec. [See Abs. 1361 (1920).] E. H. B.

349. *"Ondes de Choc" of Projectiles.* **H. Parenty.** (Comptes Rendus, 171. pp. 1190-1194, Dec. 13, 1920.)—Discusses the results obtained by Dévé [see Abs. 204 (1921)], and enumerates the results of previous experiments by the author on the form of the "ondes de choc" caused by a projectile moving with a velocity greater than that of sound.

J. W. T. W.

350. *New Method of Wind-tunnel Experimenting.* **W. Margoulis.** (Comptes Rendus, 171. pp. 997-999, Nov. 22, 1920.)—Shows that if wind-tunnel experiments were carried out in CO_2 at high pressure and temperature, it would be possible to attain practical Reynolds numbers with smaller tunnels and less power than is at present employed for model experiments. J. W. T. W.

351. *Initial Speed and Air-Resistance of High-Speed Projectiles.* **R. Ladenburg.** (Zeits. techn. Physik, 1. 9. pp. 197–205, 1920.)—By means of (1) the shapes of the waves enveloping these high-speed projectiles, and (2) a string galvanometer, the initial speeds are measured, and by comparing these with the speeds a little further on in the trajectories the air-resistances are obtained. The details of the method and of the observations are exhibited in considerable detail, the latter occupying three quarto pages. The two methods agreed very well, and projectile speeds up to 830 m. per sec. are determined. E. H. B.

352. *Uniform Translation of Solids in Infinite Fluid.* **F. E. Fournier.** (Comptes Rendus, 171. pp. 141–144, July 19, 1920.)—The author briefly discusses the uniform translation of a solid, either spherical or elongated, and of circular section, moving in the direction of its length, through a fluid which may be practically considered as extending to infinity in every direction. He also reproduces formulæ which he has obtained for the total resistance, based upon the observations of Fuhrmann and G. Eiffel, in air; and of Costanzi, in water. G. W. DE T.

353. *Velocity Distribution in the Interior of Rotating Viscous Liquids.* **W. Hort.** (Zeits. techn. Physik, 1. 10. pp. 213–221, 1920.)—The rotation of viscous liquids finds technical application, apart from machine lubrication, in certain instruments for the measurement of rotatory motions or rotatory velocities. Reference is made to Schlick's apparatus for the measurement of the rolling motion of ships, and considerable acquaintance with such instruments has induced the author to evolve the present paper on the velocity distribution in the interior of a cylinder filled with a viscous liquid and rotated in a constant direction about its axis. The paper is mathematical throughout, and replete with tables and diagrams. H. H. Ho.

354. *Molecular Transformations in Thin Films on the Surface of Water.* **H. Labrouste.** (Ann. de Physique, 14. pp. 164–238, Sept.-Oct., 1920.)—Investigations have been made on the formation of films in water by substances melting between 0° and 100° in order to ascertain whether, on fusion, these substances undergo any perceptible molecular modification, such as a variation in the magnitude of the surface covered. A new optical method of observation has been devised, and particular attention has been devoted to trimyristin, which gives especially sharp results.

At a low temperature (18°), the film of trimyristin is clearly solid, and at 23-24°, when a change is detectable, the condition of the film still recalls the solid state. The film appears, indeed, to consist of a highly dilatable solid, which becomes increasingly brittle as the temperature rises, until the solid aspect completely disappears and contraction (at 32°) yields liquid droplets. If, at this last temperature, the film is compressed until its surface is reduced to that occupied in the cold, it seems to revert to the solid state.

It is suggested that the trimyristin undergoes molecular transformation occurring not at any definite temperature, but over a certain temperature interval. In the case of fatty acids, such as oleic, lauric, and palmitic acids, the transformation is less distinct, the film remaining mobile before and after the change. T. H. P.

355. *The Brownian Movement with Consideration of a Persistence of Direction; Applications to Living Infusoria.* **R. Fürth.** (Zeits. f. Physik, 2. 3. pp. 244–256, 1920.)—When a particle experiences the effect of quickly succeeding impulses which vary quite arbitrarily in direction and intensity, a motion is produced which has the characteristics of the Brownian movement. The formula applicable to this motion has been derived by Smoluchowski [Abs. 960 (1907)] and Einstein [Abs. 664 (1906)] namely, $\bar{x}^2 = at$, where $\bar{x}^2$ is the average square of the displacement $\bar{x}$ taken for many particles of equal size in a definite direction. The formula

can be extended to three dimensions if necessary. The problem arises as to which assumptions regarding the nature of the acting impulse govern this formula, and whether that of a persistence of direction of motion involves a modification or not. Smoluchowski has shown that the formula is independent of the special nature of the distribution law of the impulse intensities. On the other hand, the directional problem has not been solved, and the present paper contains the results of an investigation to this end, employing for its purpose the motion of living infusoria. A modified formula $\overline{x}^2 = at + b(c^t - 1)$ is first mathematically derived, and experimental work then described which supports the theoretical result. Most interesting biological material has thereby been accumulated. H. H. Ho.

356. *On the Limiting Size of Colloidal Particles in a Brownian Motion : Results for Gold and Copper Particles.* **B. Arakatsu** and **M. Fukuda.** (Kyoto Coll. Sci., Mem. 4. pp. 179–182, June, 1920.)—When minute particles are in suspension in water, they are bombarded by molecules of liquid moving in very irregular ways. The force due to the impacts is resisted by inertia of the particles and viscosity of the medium. Brownian motion takes place when the former overcomes the latter, and the motion becomes less pronounced as the size of the particle gets larger and the viscosity increases. Barton states that particles cease to move when the diameter exceeds about $4\,\mu$, but he does not describe the nature of the solution or the viscosity of the medium. The authors found silver particles of about $2{\cdot}5\,\mu$ to be in a state of rest, while in gamboge sol vivid motions were observed even in greater particles. In consequence a more minute study of the subject has been made. The colloidal solutions used, namely of Au, Ag, Cu, Cd, Zn, Sn, Mg, Ni, Al, and W, were prepared by Bredig's method. Mercury suspension in water was also investigated. Experimental details are given.

Results.—In Bredig's colloids the limiting size is found to be about $2{\cdot}6\,\mu$ for all the metals examined. The relation of this limiting size to the viscosity of the continuous phase was found by utilising the fact that sols have viscosities very slightly higher than those of the media, and therefore are approximately the same. In the experiment the viscosity was varied by adding a concentrated solution of sugar or glycerin to the sol, and the viscosities of the sols thus treated were measured by a viscosimeter. A drop from such a solution was examined under the ultra-microscope for limiting size. A table of results for gold and copper is given.

H. H. Ho.

357. *Einstein Shift of Spectral Lines.* **O. J. Lodge.** (Nature, 106. p. 280, Oct. 28, and p. 373, Nov. 18, 1920.)—The author has suggested seeking for the Einstein shift under centripetal acceleration, and Rayleigh, while pointing out that the predicted shift depends, not on gravitational intensity, but on gravitational potential, had suggested to him that, since the shift is proportional to u^2/c^2, the high speed of positive rays curved in a magnetic field might facilitate its detection, in that, if their speed were 10^8 c.g.s., their radiation shift would be comparable to a fortieth of an Ångström unit. But this proportionality, the author observes, raises the question whether, after all, the expected shift is anything more than the natural consequence of self-inductive increase of inertia due to speed. If a satellite suddenly gained a spurious inertia

not subject to attractive force, its orbit would enlarge and its period lengthen. So it may be with electrons in a violently projected Bohr atom. **C. Chree** (*ibid.*, p. 343, Nov. 11, 1920). G. W. DE T.

358. *A Suggestion for the Representation of Space–Time Relations in the Special Theory of Relativity.* **F. P. Liesegang.** (Phys. Zeits. 21. p. 675; Disc., 675, Dec. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—The suggestion is based on an idea of Minkowski, and consists in effecting the Lorentz transformation to an oblique-angled coordinate system. The coördinates of this system are then denoted by such units that they afford valid values for moving bodies. The system thus obtained is shown to express the space–time relations in the special theory of relativity. H. H. Ho.

359. *Critical Remarks on the Basis of the Theory of Relativity.* **H. Dingler.** (Phys. Zeits. 21. pp. 668–675, Dec. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—The paper first pays a tribute to the value of Einstein's work and its significance in modern physics, and then discusses the problems of motion in space and definition of time which are grouped under the heading of orientation problems. A sharp differentiation is made between motions of geometrical figures and of actual bodies, the former belonging to kinematics and the latter to mechanics. In the relativity theory both these ideas are shown to be continually mixed at the expense of clarity. The author then deals with the problem of the determination of actual motions. The paper is philosophical and critical throughout. H. H. Ho.

360. *Stellar Photograph Evidence for Einstein's Relativity Theory.* **B. H. Crookes.** (Chem. News, 121. p. 239, Nov. 12, 1920.)—The author, on the basis of hitherto unpublished experiments by W. G. Crookes, suggests that the displacements of the star images obtained in the 1919 eclipse, and accepted as evidence of the truth of Einstein's theory, may have occurred, not during exposure, but subsequently during development and fixing. That the latter can occur in photographs of spectra of the elements was suspected, tested, and proved by him, the test being made in the following manner: A negative, with two spectra, slightly overlapping, was selected, which had at one part of it a group of strong lines, and at another part few and weak lines. From this negative a contact positive was printed, and from the positive another contact negative. The two negatives were then measured in the usual manner, along the overlap of the two spectra, and compared, and the following results noted: (*a*) the whole negative altered in length; (*b*) the alteration took place in a "concertina" fashion, being greater where the lines were strong and numerous than where they were light and few; (*c*) one or two lines showed decided displacement with regard to their neighbours in the same spectrum. The conclusion drawn was that during development and fixing the sensitive film was in a state of tension, and yielded to the strain irregularly in proportion to the depth and width it had been altered by the light rays. It would then seem that the spectra had been measured along the very worst line, where distortion would be greatest, and arrangements were being made to alter the shuttering of

the spectroscope so that the measurements could be taken along a line only just off the unexposed part of the plate, where distortion would be least, but death intervened, and the alteration was never made. In the case of stellar photographs there would appear to be no line of weakness, but in the eclipse the ring of flames would form a very decided line of weakness, and the author suggests the desirability of examining the possibility of the displacements having arisen from the sensitive films having yielded to strain in its neighbourhood during developing and fixing. If this should be the case, a similar effect should be found, he suggests, during an annular lunar eclipse, and it might even be possible to obtain evidence of slight displacement during a close conjunction of a star with Jupiter or Venus when at their brightest. Bright star clusters might also show systematic divergencies between the photographic and visual positions. G. W. DE T.

361. *On the Permanent Movement in Liquids.* **L. Lecornu.** (Comptes Rendus, 171. pp. 881–885, Nov. 8, 1920.)—In the constant movement obtaining in liquids, the molecular trajectories are fixed curves whose disposition depends on external forces. Where any forces whatever may exist nothing can be stated *a priori* concerning this arrangement, but it is otherwise where the forces are derived from a potential, and this case forms the subject of the present paper. The treatment is mathematical throughout, and includes the necessary condition for the absence of turbulence. It is found that at two instants sufficiently removed and corresponding to the different states, the variation of speed and of pressure at a fixed point arbitrarily chosen is sufficient for the calculation of the corresponding variations throughout the mass.
H. H. Ho.

362. *A Dynamical Cubic Atomic Model.* **E. Madelung** and **A. Landé.** (Zeits. f. Physik, 2. 3. pp. 230–235, 1920.)—The dynamical treatment of the cubic atomic model formed of 8 electrons, depends on the reduction by means of symmetry conditions of the 8-body problem to that of a single body. The disadvantage of this model is, firstly, in the possession of essentially higher potential energy than the plane 8-ring system, and secondly, that by the action of external forces the orbit disturbances produced are of much higher dimensional orders than those of the disturbing forces. Both these defects have been avoided in the model now described, which consists in the combination of two tetrahedral models. The paper itself is entirely mathematical [Abs. 531 (1919) and 1371 (1920) should be consulted]. The cubic atomic model produced, possesses an appreciably smaller total energy than the plane 8-ring system, while the spacial arrangement is shown to possess much greater stability. H. H. Ho.

363. *Note concerning the Basis of the Relativity Theory.* **K. Wessely.** (Phys. Zeits. 21. pp. 549–551, Oct. 15, 1920.)—An axis Ox at rest, upon which t identical clocks are arranged has superposed a moving axis $O'\xi$ of velocity v and carrying τ clocks. A light signal is dispatched at time $t = O$ from O to M at the distance x, received at M at the time $t_1 = O'M/(V - v)$, and after reflection again received at the origin of the ξ axis at time $t_2 = O'M/(V - v) + MO'/(N + v)$, where V is the velocity of light and $OO' = vt_1$. Should the hand of the τ clock at M when the light reaches it show half the reading which the τ clock shows

at the origin at its return, then the hands of the τ clocks from the beginning onwards must be displaced at a distance ξ an amount proportional to ξ. The consequences of this proposition are worked out in the present paper, which also includes a note on the addition theorem. H. H. Ho.

364. *Constitution of the Elements; Minimum Number and Masses of Isotopes.* **F. W. Aston.** (Nature, 106. p. 468, Dec. 9, 1920.)—The author gives the results of his positive-ray spectrum experiments with a few more elements. The work has been progressively more and more difficult, for it has been not easy to find suitable volatile compounds, and when found the very objectionable chemical properties of some of them have led to experimental trouble and disappointing results. Thus selenium, tin, antimony, and tellurium have so far yielded no result of any value.

The following table gives the up-to-date results of the author.

TABLE OF ELEMENTS AND ISOTOPES.

Element.	Atomic Number.	Atomic Weight.	Minimum Number of Isotopes.	Masses of Isotopes in Order of their Intensity.
H	1	1·008	1	1·008
He	2	3·99	1	4
B	5	10·90	2	11·10
C	6	12·00	1	12
N	7	14·01	1	14
O	8	16·00	1	16
F	9	19·00	1	19
Ne	10	20·20	2	20, 22, (21)
Si	14	28·30	2	28, 29, (30)
P	15	31·04	1	31
S	16	32·06	1	32
Cl	17	35·46	2	35, 37, (39)
A	18	39·88	2	40, 36
As	33	74·96	1	75
Br	35	79·92	2	79, 81
Kr	36	82·92	6	84, 86, 82, 83, 80, 78.
I	53	126·92	1	127
X	54	130·32	5, (7)	129, 132, 131, 134, 136, (128, 130 ?)
Hg	80	200·60	(6)	(197–200), 202, 204

(Numbers in parentheses are provisional only.)

A. B. W.

365. *Physics of Atoms, Spectra, and Atomic Structure.* **A. Sommerfeld.** (Phys. Zeits. 21. pp. 619–621, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—The first section deals with the hydrogen spectrum and with spectra dissimilar to that of hydrogen. It is shown that the fine structure in the case of the hydrogen lines corresponds with the coarse structure of the spectra of other substances. For the fine structure in other cases, as in

the case of the doublets in the spectra of the alkalies, there is no analogue in the hydrogen spectrum. The second section discusses the question of the cubical arrangement of electrons in atomic structure. A. W.

366. *Charge on the Atomic Nucleus and the Law of Force; Validity of the Inverse Square Law for the Pt Atom.* **J. Chadwick.** (Phil. Mag. 40. pp. 734–746, Dec., 1920.)—The charges of the nuclei of three atoms, namely those of platinum, silver, and copper, have been measured by a direct method depending on the scattering of α-particles. The values found are 77·4, 46·3, and 29·3 respectively in fundamental units of charge. The atomic numbers of these elements are 78, 47, and 29.

The law of force around the Pt nucleus has been tested by the dependence of scattering on the velocity of the α-particle. The results show that the inverse square law holds accurately in the region concerned, viz., around 10^{-11} cm. from the nucleus.

"The good agreement between the measured values of the nuclear charges and the atomic numbers of the elements deduced from the X-ray spectra affords strong confirmation of Moseley's generalisation. Owing to the probability fluctuations, it is hardly possible to attain sufficient accuracy in the measurements to prove that the charge on the nucleus is a whole number of times the electronic charge. At present this is only possible in one case—that of the helium nucleus or α-particle. There can, however, be little doubt that the nuclear charge does really increase by unity as we pass from one element to the next, and that its net value is given by the atomic number.

"The values of the nuclear charge combined with the dependence of scattering on the velocity of the α-particle, as indicated by Rutherford's theory, show that the inverse square law of force holds to a high degree of accuracy in the region investigated, 10^{-11} cm. from the nucleus of a heavy atom like platinum. The experiments of Geiger and Marsden on the angular distribution of α-particles scattered by gold between 5° and 150° show that the same law must hold for distances between $3{\cdot}1 \times 10^{-12}$ cm. and 36×10^{-12} cm. from the nucleus. Further, the agreement between the experimental measurements of the K-series spectra and the theoretical values of Debye and Kroo shows that the inverse square law still holds at the K-ring. In the case of Pt the radius of the K-ring is about 10^{-10} cm.

"Thus, measured from any point in the region between 3×10^{-12} cm. and 10^{-10} cm. from the nucleus of the heavy Pt atom, the charge is equal to the atomic number and the law of force is the inverse square. We may therefore conclude that no electrons are present between the nucleus and the K-ring." A. B. W.

367. *Solar Variation and the Weather.* **H. H. Clayton.** (Nature, 106. pp. 468–469, Dec. 9, 1920.)—Solar radiation measurements are employed by the Argentine Meteorological Office as a basis of forecasting, estimated daily temperatures and notices of expected rains being given for a week ahead. The aim of the present note is to give the conclusions to which a study of an immense amount of data from all parts of the world has led. Firstly, the effect of solar radiation is cumulative, and the response in atmospheric action to a prolonged period of high or low solar radiation is much greater than that to a shorter period of greater ntensity. Secondly, as the sun changes from one hemisphere to the

other the effect on the weather changes, so that, in the hemisphere where the sun is nearly vertical, pressure falls over the land and rises over the water surface, with the opposite effect in the other hemisphere. Although this may be taken to indicate that a large proportion of increased solar radiation reaches the earth's surface, yet there are indications that a considerable part is absorbed by the upper air and gives rise to atmospheric waves. These have been examined by separating solar and weather changes into longer and shorter waves. For the former, 10-day averages give correlations exceeding 80 %. The correlations for the latter are not so great, but certain difficulties arise in this case.

A marked excess or defect of solar radiation tends to be repeated after 10 to 13 days, which is taken as evidence that the origin of marked deviations from normal lies in the region of the prominences and not in that of sun-spots. In conclusion, the high correlation between variations of solar radiation and the weather, found in the Argentine and elsewhere, leads the author to believe that, apart from the well-known diurnal and annual changes, these are the chief, if not the only, cause of weather changes. M. A. G.

368. *Predicting Minimum Temperatures from Hygrometric Data.* **C. F. Marvin, J. W. Smith.** (Monthly Weather Rev. Suppt. No. 16. pp. 1–76, 1920.)—In the introduction C. F. Marvin outlines a "star point method" of fitting a curve to plotted data. This consists in selecting, by inspection, just sufficient points, representative of the data, to determine a curve of the desired degree and noting their co-ordinates. The coefficients in the equation are then determined from these coordinates. For the present purpose the accuracy obtained is sufficient and the labour of the method of least squares avoided.

In the second part, a relationship is sought by J. W. Smith between the minimum temperature on "radiation nights" and the evening's relative humidity. Plotting variation of the minimum temperature from the dew-point against the previous evening's relative humidity, it is found that a parabola fitted by the above method gives a satisfactory representation. A large number of stations are examined and the parabolic relationship is found to be general, though the coefficients differ from place to place and in some cases have a seasonal variation. The application is to the prediction of the minimum of the ensuing night to enable adequate protection of crops to be made. The paper is to be regarded as pointing the way to the use of evening, and probably the noon, psychrometric data for the purpose in hand.

The remainder, and by far the greatest part, of the publication consists of contributions by Weather Bureau officials actually engaged, in various parts, in local forecasting of minimum temperatures for practical purposes, giving the methods which have been developed in each case. M. A. G.

369. *Suggestions concerning C. G. Abbot's Programme for Four World Observatories for the Observation of Extra-terrestrial Solar Radiation.* **C. Dorno.** (Monthly Weather Rev. 48. pp. 348–351, June, 1920.)—Entire agreement is expressed with the plan to make a careful investigation of the cloudiness of selected places before finally deciding on them as situations for the observatories, but it is suggested that the apparatus in use now at Davos, Switzerland, for measuring the illumination, sun

plus sky, on a horizontal surface, would be preferable to Abbot's photographic method for this purpose. The Davos photoelectric apparatus, in which a highly evacuated potassium cell is exposed horizontally under a filter (Schott F 5899) and a milk-glass plate, is highly sensitive not only to the effect of cloud, but also of any other opacity of the atmosphere such as dust. It is further suggested that the use of an instrument similar to K. Ångström's "tulipan" may obviate the objection raised by Abbot that for wave-lengths greater than 15 μ the absorption of the surface of the instruments in use to-day has not been sufficiently investigated. However, comparative observations, made by the author, with Ångström's pyrgeometer and by tulipan show a fairly constant ratio. An exact determination of the ozone content of the atmosphere is important on account of its absorption for wave-lengths about 10 μ. This presents great difficulties, but it is suggested that photoelectric intensity measurements with a cadmium cell in the spectrally decomposed ultra-violet would be successful. Finally, for investigations in the infra-red, bacteria can be advantageously substituted for photographic plates.
M. A. G.

370. *A Nomogram for Air Density.* **W. Block.** (Zeits. techn. Physik, 1. 12. pp. 278–280, 1920.)—Describes a simple nomogram for obtaining the density of the air from the pressure, temperature, and humidity. The allowance for humidity is made as a correction to the temperature. Numerical tables are published elsewhere (Zeits. f. Instrumentenk. 40. pp. 205–209, Nov., 1920). M. A. G.

371. *Halo Display Observed at Ellendale, North Dakota; Complete Secondary Parhelic Circle Observed.* **F. J. Bavendick.** (Monthly Weather Rev. 48. pp. 330–331, June, 1920.)—Describes halo phenomena observed at Ellendale on March 8, 1920, the display being fullest at 1.30 p.m. There were visible the 22° halo, an arc of the 46° halo, arcs of a circumscribed halo, parhelia of 22° halo, anthelion, infralateral tangent arcs of 46° halo, parhelic circle, two pairs of the oblique arcs of the anthelion, and so-called vertical parhelion of 22°. In addition and of greatest interest was a secondary parhelic circle within and concentric with the primary and tangent to the 22° halo and the oblique arcs of the anthelion. In an added note **W. R. Gregg** mentions that so far as is known a complete secondary parhelic circle has never before been observed. A portion of one was observed in 1896 by A. v. Kalmar at Pola. M. A. G.

372. *Researches on Surface Air.* **P. B. Huber.** (Archives des Sciences, 2. pp. 508–510, Nov.–Dec., 1920. Paper read before the Soc. Suisse de Géophysique.)—P. Olujic has examined the emanations from clayey soil and has found that the ionisation near the surface is much less when the soil is damp than when it is dry, also when it is compact than when it is broken up, and further that it is almost nil over snow. The present writer has conducted similar experiments over gravel, and finds confirmation of the above in that greater ionisation accompanies dry soil than wet and so on, but the percentage differences are not the same as for a clay soil. Besides, the absolute values appear higher over gravel. These results were obtained with apparatus consisting of a cylindrical sheet-iron receiver 30 cm. wide and high, open at the base and with a hole of diam. about 8 cm. at the top. A plate, 15 cm. in diam. and 15 cm.

from the ground, was connected through this hole with an electrometer above. The experiments were made between 13h. 30m. and 14h. 15m.

It is known that during the " Föhn " the ionisation of the air is above normal. The present experiments show that this is not due solely to the descent of strongly ionised air from higher levels, but that at the same time the emanations from the surface are above normal. Other cases of strong ionisation are mentioned, which on investigation proved to be confined to a layer 20 to 30 m. above the surface, the ionisation at 50 m. being normal. This condition is observed to precede a change of weather. M. A. G.

373. *The Boulder Halo of January* 10, 1918. **E. W. Woolard.** (Monthly Weather Rev. 48. pp. 331–332, June, 1920.)—The max. development was about 10 a.m., one-hundred-and-fifth meridian time, though some portions of the display persisted throughout most of the day. The complex included a curved sun-pillar, the 22° halo, parhelia of 22° halo, the 46° halo, parhelia of 46° halo, circumzenithal arc, parhelic circle, paranthelia, portions of paranthelic arc, and also " Parry's upper arc." At this time the sun's elevation was 19° 50′ and the atmosphere was filled with falling ice crystals, the temperature being — 4° F. and the air very quiet. A simple geometrical method is given of locating points on the " Parry " arc, which is produced by refraction through randomly oriented ice-needles each having a pair of side faces horizontal. M. A. G.

374. *Historical Cases of Excessive Atmospheric Refraction.* **P. L. Mercanton.** (Archives des Sciences, 2. pp. 513–515, Nov.–Dec., 1920. Paper read before the Soc. Suisse de Géophysique.)—Surface inversions of temperature in the polar regions are often capable of producing excessive atmospheric refraction and may, towards the end of the polar night, render the sun visible several days before the time of rising calculated from astronomical considerations alone. The effect of such a distribution of temperature is to raise the horizon ; in spite of this, however, a celestial body, not otherwise visible, may be brought into view owing to the rays from it traversing the lower atmosphere twice. Details are given of four cases of the early appearance of the sun in polar regions, the estimated elevation due to refraction being 2·4, 1·3, 2·2, 2·3 degrees respectively. M. A. G.

375. *Measurement of the Vertical Component of the Wind by Means of Mill Anemometers.* **C. E. Brazier.** (Comptes Rendus, 171. pp. 1227–1229, Dec. 13, 1920.)—Direct measurements of the vertical component of the wind by various observers in various places have, when averaged over a period, shown at all seasons a balance of ascensional movement of the order of 0·5 m./sec. The author seeks to explain this paradox on the basis of some experiments on the form of anemometer commonly employed in the above observations. It consists of four blades inclined at 45° to the vertical and joined by equal arms to a nave carried on a vertical pivot, and it has always been assumed that the speed of rotation is proportional to the vertical component of the wind. The present experiments show, however, that this assumption is not justified and that only a fraction of the vertical component is registered. Further, this fraction depends on the inclination of the actual wind to the horizon and increases from zero for a horizontal wind to unity for

a vertical wind. Now although on the average ascending and descending masses of air may have equal vertical components, near the surface the mean wind speed increases rapidly with height and hence an ascending mass of air will on an average move in a direction inclined at a greater angle to the horizontal than a descending mass; for the latter will have the greater horizontal component. Hence a greater fraction of the vertical component of the former will be registered, with the above paradoxical result. M. A. G.

376. *Rare Gases in the Natural Gas of Alsace-Lorraine.* **C. Moureu** and **A. Lepape.** (Comptes Rendus, 171. pp. 941–947, Nov. 15, 1920.)—The examination of the natural gases from the petroleum mines of Pechelbronn, salt mines of Wittelsheim, coal mines and two mineral springs at Niederbronn and Sulzmatt, confirms the conclusions arrived at [see Abs. 446 and 1716 (1912) and 889 (1914)] concerning the natural gases of France. Nitrogen and the rare gases are always present; oxygen is absent, except in the mineral spring of Sulzmatt; all springs rich in CO_2 seem to contain also oxygen. The ratio Argon/Nitrogen (1 for air) varies between 0·9 and 2·48; neon, krypton, and xenon are present in very small percentages not determined; the ratio Helium/Argon is very variable as elsewhere. The nitrogen of gases rich in hydrocarbons (oil and potash mines) can hardly be of organic origin, as the Helium/Argon ratio increases rapidly with the depth of the origin; the probability of the presence of radio-active elements and of lead at greater depths is strengthened; there are exceptions to this rule, however. The max. depth of the mines referred to in this paper is 550 m. H. B.

377. *Wells and the Permeability of Soils.* (Engineering, 110. pp. 856–857, Dec. 31, 1920.)—The velocity v of the flow (assumed to be capillary) of water through the pore-spaces in a sand, small gravel, soil, etc., may be estimated after Poiseuille $v = cd^2h/lw$, where d is the diameter of the pipe, l its length, h the pressure head and w the viscosity of the water. In a porous medium d and l cannot be measured, but d is related to the grain size. In water-bearing sandstone $d = 0·15$ mm., in sand up to 0·4 mm., in fine soil and in argillaceous soil from 0·001 and 0·002 up to 0·032 mm.; hence the flow of water will be thousands of times greater through sands than through argillaceous soil and silts. If the sand grains were all of uniform size, the pore-space would vary between 25·95 and 47·64 % according to the packing; if the water present exceed saturation, the sand will flow. By infiltration of smaller grains the porosity is lowered to less than 25·95 %. The author discusses the grading of sand after A. Hazen and the formulæ for the flow of water through sand after Hazen and Slichter, and refers also the experiments and observations of Clibborn and others. The flow of underground water, which is strongly influenced by temperature, is very slow. Clibborn found in sand with clay and loam a rate of 1 mile per year; Rohlfeist in coarse sand and glacier drift from 1·6 to 13 ft. per day, and in gravel 16 to 328 ft. per day. H. B.

378. *Substances Dissolved in Rain and Snow.* **W. A. Moore** and **G. Browning.** (Chem. News, 122. pp. 51–52, Feb. 4, 1921.)—The specimens examined were collected in an open space near a small village in Iowa, 18 miles from the nearest manufacturing centre. The tests were

spread over the period from May 31 to Aug. 13, 1920, precipitation falling on 21 occasions and totalling 6·13 in. Tests were made for nitrogen in nitrites and nitrates, free and albuminoid ammonia. Phosphates, sulphates, and carbon dioxide were also found at times. For the summer months the averages were: ammonias 0·28, nitrates 0·35, carbon dioxide 0·23 parts per million, the amount of nitrogen as nitrates and nitrites which fell during this period being 0·76 lb. per acre. Nitrogen in excess of the normal was expected during thunderstorms but not found. Relatively large amounts of the various substances were found when the precipitation was small. Carbon dioxide and sulphates were almost invariably present when the wind was from the manufacturing centre previous to the rainfall. A decrease in the amount of nitrites and nitrates was found with rain following previous rain on the same or the preceding day. M. A. G.

379. *Problems of Cosmogony; Reply to Reviewer's Criticism.* **J. H. Jeans.** (Observatory, 43. pp. 389–391, Nov., 1920.)—The author's book under the above title was reviewed by MacMillan in the June number of the Astrophysical Journal, and the reviewer took exception to the suggestions of a possible 66-fold increase in the linear dimensions of a system, arguing that this could not be more than two-fold, without considerable alteration of internal conditions. In reply, the author makes suggestions to account for what he considers the reviewer's misconception, and finds an absolute limit of 116, for the ratio which he guessed at 66. He is prepared to admit that the real figure is less than 66 for reasons given, connected with conservation of momentum and energy taken together, but observes that we do not profess to know all the sources of energy and forms of force in the universe, without which knowledge there is bound to be a considerable margin of doubt.
W. W. B.

380. *Einstein Effect in Solar Spectrum.* **L. Grebe** and **A. Bachem.** (Zeits. f. Physik, 2. 4. pp. 415–422, 1920.)—Describes further work on the displacement of the lines of the nitrogen band λ3883, due to the gravitational field of the sun [Abs. 1171 (1920)]. Results are obtained in close agreement with those of Schwarzchild and others, and confirm Einstein's theory both as regards the direction and magnitude of the observed displacement. A. W.

381. *The Gravitational Displacement of the Fraunhofer Lines.* **L. Grebe.** (Phys. Zeits. 21. pp. 662–666; Disc., 666–668, Dec. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—The difficulties attending the experimental measurement of line displacements are first discussed, and the conclusion is drawn that the nitrogen bands, which had earlier been ascribed to cyanogen, are especially suitable for the purpose, since they are free from the phenomena of anomalous dispersion. The author next describes his own experiments made in collaboration with Bachem. The carbon arc is stated to be free from objection for the production of a comparison spectrum. The work of Schwarzschild, St. John, Evershed, and Royds is then briefly discussed. Different lines are found to give different displacements, and the general result derived is that evidence has been obtained in support of the line displacements in amounts demanded by the Einstein theory. An

independent method is then described leading to a like result. This is based on the rejection of the lines of too great displacement and the discovery that the lines of small displacement are more suitable for the purpose in hand. A general discussion on the theory of relativity by Lenard, Einstein, Rudolph, Palagyi, Born, Mie, and Kraus is included in the paper. H. H. Ho.

382. *On the Einstein Terms in the Motion of the Lunar Perigee and Node.* **W. de Sitter.** (Roy. Astron. Soc., M.N. 81. p. 102, Nov., 1920.)—In this note the author corrects the general formula for the motion of the lunar perigee and node which has been erroneously printed in his former paper "On Einstein's Theory of Gravitation and its Astronomical Consequences" [see Abs. 291 (1917), and 134 (1918)]. From the formula, it appears that the motion depends only on the elements of the earth and not on those of the moon. A. D. Fokker is about to publish a paper in the Proceedings of the Academy of Sciences at Amsterdam in which the same motion is found by introducing a system of axes taking part in the motion of the earth, the time-axis being always tangent to the earth's world-line, and the space-axes remaining perpendicular to the time-axis and parallel to themselves. He shows that with reference to these axes the equations of motion are, with sufficient approximation, Newtonian. H. H. Ho.

383. *New Method of Calculating Altitude.* **S. Ogura.** (Phys. Math. Soc. Japan, Proc. 2. pp. 241–242, Dec., 1920.)—If l is latitude of place of observation and h, d the hour-angle and declination of the heavenly body, the altitude a is given by

$$\text{Sin } a = \sin l \sin d + \cos l \cos d \cos h.$$

Put $H \sin K = \sin l$ and $H \cos K = \cos l \cos h$ or $\tan K = \tan l \sec h$; $H = \sin l \operatorname{cosec} K = \cos l \cos h \sec K$. Then $\sin a = H \cos (d - K)$ or $\operatorname{cosec} a = 1/H \cdot \sec (d - K)$. Thus

$$10^5 \log \operatorname{cosec} a = 10^5 \log \frac{1}{H} + 10^5 \log \sec (d - K)$$

or

$$C = A + B.$$

In table A, A and K are tabulated for every degree of latitude and hour-angle; in Table B, B is tabulated for every minute of $d - K$; in Table C, $C = A + B$ is tabulated for every minute of a. The author states that without interpolation the value obtained will be correct within 1′ and generally within ½′, that the tables may be used as far as 65° latitude N. or S. without limitation of declination, and only occupy 31 octavo pages. W. W. B.

384. *Elements in the Sun.* **M. N. Saha.** (Phil. Mag. 40. pp. 809–824, Dec., 1920.)—Certain elements, as Ca, Fe, V, and Ti are unusually prominent in the solar spectrum: others, Rb, Cs, N, P, S, Se, etc., have as yet shown no evidence in the sun: some have received doubtful identification, *e.g.*, W, U, Ta, etc.: others again give faint indications in the Fraunhofer spectrum. It is *a priori* probable that the sun does nevertheless contain all the elements found in the earth, and the author's purpose is to consider why they do not appear. He urges that the atomic weight

is not a sufficient reason, since N is absent just as Th is, and proposes the theory that "the varying records of different elements in the Fraunhofer spectrum may be regarded as arising from the varying response of these elements with regard to the stimulus existing in the sun. The stimulus existing in the sun is the same for all elements, namely, that arising from a temperature of about 7500° K., but owing to different internal structure, elements will respond in a varying degree to this stimulus." In a previous paper [Abs. 218 (1921)] and in a paper not yet published "on the temperature radiation of gases," he sketches the manner in which the effect of the stimulus can be quantitatively estimated. In the first of these Ca, Sr, and Ba were considered. The present paper deals with Na, K, Rb, Cs, O, Mg, N, and He, from the point of view of the ionisation potential.

He considers that the elements apparently missing may be divided into two groups—(1) those completely ionised, *e.g.*, Rb, Cs, and probably Th, and (2) those whose ionisation and radiation potentials are so high that they cannot absorb those of their characteristic lines occurring in the continuous spectrum. This group includes He and the other inert gases, and probably also the metalloids As, Sb, Bi, etc. In connection with unidentified lines he urges attention to the solar faculæ as representing a higher temperature than the photosphere. W. W. B.

385. *Law of Distribution of Masses in Solar System and Origin of Minor Planets.* **E. Belot.** (Comptes Rendus, 171. pp. 704-707, Oct. 18, 1920.)—Pursuing his research into a possible explanation for the fact that the minor planet region separates four large and light planets from four small dense ones [see Abs. 400 (1909)], the author considers what would happen while the proto-sun's temperature rapidly decreased from 15,000° to 7500°. The radiation-pressure proportional to the fourth power of the absolute temperature would have 10 to 16 times greater repulsion on particles as light as water-vapour, as upon (*e.g.*) iron oxide and other heavy compounds for which consequently gravitation would overcome the repulsion. The minor planets, according to the author, occupy a limiting region between those where radiation-pressure is greater than gravitation and where it is less. This region is bounded by two paraboloids described about the sun as focus and the sun's path as axis. He obtains a law of distribution of masses of the exterior planets $m = 0{\cdot}02584\,M/r^2$, M being the sun's mass and m, r respectively the mass and distance of the planet. The constant is chosen to fit Jupiter, and the discordance for Saturn is less than 1 %, but the only way to make an approximate fit for Uranus and Neptune is to take them together. The formula assumes a mean distance of 0·1607 from the centre for the mass of the sun itself, since the density cannot be taken as infinite at the centre.

He supposes that the density of the minor planets increases as their aphelion distances diminish, in the same way as the outer planets, and suggests that comets also fit into the theory, and that a generalisation of it will account for the dark rifts in the Milky Way, and the nebulosities surrounding novæ. W. W. B.

386. *Relation between Solar Activity and Brightness of Eclipsed Moon.* **A. Danjon.** (Comptes Rendus, 171. pp. 1127-1129, Dec. 6, 1920.)—The author announces that in the two years following sun-spot minimum

the earth's shadow is very dark, grey, or neutral tinted. After this the eclipsed moon appears brighter and brighter, and more and more red in colour until during three or four years before the next minimum it is very bright, copper-red, or orange. There is nothing special to mark the maximum, but the change at minimum is sudden. These conclusions are derived from consideration of about 150 eclipses, of which exact descriptions are available from the time of Tycho Brahé onwards. The plotted results on a scale of tints resemble the teeth of a saw. Two curves are given, one from the mean of eclipses used from 1823 to 1867, and the other from 1867 to 1920. The eclipses before 1823 have not been used for the purpose of deducing a law. Moreover, these eclipses about 1884 which were dark instead of bright have also been omitted, their abnormal character being attributed to the eruption of Krakatoa.

The author proposes to investigate ancient eclipses in the same way.

W. W. B.

387. *New Determination of Solar Period based on Law of Brightness of Eclipsed Moon.* **A. Danjon.** (Comptes Rendus, 171. pp. 1207–1210, Dec. 13, 1920.)—The relation announced [see preceding Abs.] has now been tested for solar minima before 1823. In those times sun-spots were not regularly observed and the dates of minima are uncertain, as determined by Wolf. The author finds discrepancies between Wolf's dates and those found from the law of brightness of the eclipsed moon, the greatest one of 5 years, Wolf having a minimum in 1611, when the author finds a maximum. His formula for minima is $1584{\cdot}8 + 10{\cdot}87\,E$, E being the number of periods since 1584. From the residuals between computed and observed dates he obtains a sine-curve with a period of 136 years, which reduces the mean error from 1 year to 0·4 year. There are some gaps in the series used, but though the author would like to test his two periods, 10·87 years and 136 years, over a longer series, observations before 1583 are too few and scattered. He predicts the next minimum for 1923–4, until which time lunar eclipses should be getting brighter, and then dark till 1926.

W. W. B.

388. *Spectrographic Methods of Measuring Diurnal Rotation of Planets.* **V. M. Slipher.** (Observatory, 43. pp. 391–393, Nov., 1920.)—In reply to a paper [see Abs. 1482 (1919)] which, while advocating a new method appeared to belittle the accuracy of the "inclination" method frequently used by the present author and others on the ground principally of "guiding error" effect, the author in this paper defends the method, arguing that the guiding in modern instruments is better than the seeing conditions, and that this error is practically absent from his Venus observations. He gives other reasons in support of the "inclination" method, and considers the alternative proposed not to be applicable in this particular case, besides being also very much affected by guiding error.

W. W. B.

389. *Fine Calcium Lines: their Source in the case of* 12 *Lacertæ.* **R. K. Young.** (Dominion Astrophys. Observat. Victoria, Publ. Vol. 1. Observatory, 43. p. 399, Nov., 1920. Abstract.)—The amplitude of the radial velocity curve of the spectroscopic binary 12 Lacertæ varies from night to night between 15 and 70 km./sec. When the amplitude is small the lines are in general more diffuse. The velocity of the centre of gravity of the system towards the earth has steadily increased since

1913, and is probably subject to a long-period variation. The fine Ca lines share in this variation, thus confirming the author's previous conclusion that the source of these lines is a large Ca cloud surrounding the system and moving with it. W. W. B.

390. *New Asteroids belonging to the Families.* **K. Hirayama.** (Phys. Math. Soc. Japan, Proc. 2. pp. 236–240, Dec., 1920.)—The author examines the elements of the 120 new asteroids to be added to those previously discussed [see Abs. 1050 (1918) and 697 (1919)], in order to distribute them among his suggested families and to find further evidence for the reality of these families. Comparing the numbers to be expected in each region from a random distribution with those actually obtained, he finds support for the reality of the families, with some modifications of these, especially in the suppression of a separate Alice group, which is to be merged in the Flora family. A complete table is given of the members of the five families thus indicated (Themis, Eos, Koronis, Egeria, and Flora), and a suggestion is added that two more families may be expected, one of greatly inclined orbits, to include Pallas and Zerlina, and another with great eccentricities to include Albert and Alinda. W. W. B.

391. *Photographic Parallaxes.* **F. Schlesinger.** (Allegheny Obs. Publ., Vols. 4, 5, and 6. Nature, 106. p. 482, Dec. 9, 1920. Extracts.)—The first two of these volumes contain nearly 300 stellar parallaxes with average probable error $0''\cdot008$. These include the following large ones:

τ Cygni	$0''\cdot058$	OΣ 547 (mean)	$0''\cdot103$
ι Pegasi	$0''\cdot067$	Furuhjelm star	$0''\cdot099$
μ Pegasi	$0''\cdot043$	χ Orionis	$0''\cdot096$
β Virginis	$0''\cdot096$	8 Canum Ven.	$0''\cdot109$
42 Coronæ	$0''\cdot064$	ξ Boötis	$0''\cdot147$
ζ Herculis	$0''\cdot114$	η Cassiopeiæ	$0''\cdot173$
μ Herculis	$0''\cdot104$	61 Cygni (mean)	$0''\cdot285$
85 Pegasi	$0''\cdot084$	Castor (mean)	$0''\cdot070$

Many of these stars have yielded parallax determinations with a considerable range, but the great improvement in the photographic method in recent years, especially by the use of a rotating sector or other device to equalise magnitudes and confining attention to the meridian in order to minimise the effect of atmospheric dispersion, greatly increase the confidence with which these new determinations are given.

Effect of Atmospheric Dispersion on Parallaxes. **C. J. Hudson.** The third volume noted contains a paper on the amount of error arising from atmospheric dispersion. At considerable hour-angles, East and West, the effect on pairs of plates is $0''\cdot021$, but owing to the precaution mentioned above, the effect on the Allegheny parallaxes is negligible. W. W. B.

392. *Nova Aquilæ* No. 3. **I. Yamamoto, Y. Ueta,** and **K. Kudara.** (Kyoto Coll. Sci., Mem. 4. pp. 23–42, Sept., 1919.)—The first observations of the nova by two of the authors were made at the Eclipse Expedition to St. Peter's Island in N.W. Pacific. On their return they found that K. Kudara had begun observations. The observations of all three are given in detail, as also those of two other observers, T. Sasaki and R. Furukawa. Most of the reductions were made by K. Kudara,

who also took meridian observations of the position of the nova. Twenty-four spectrograms were obtained covering the bright-line stage of the nova. H_β, H_γ, and H_δ are very bright and wide. Intensity curves are given, one visual and five photographic, and reproductions of four spectrograms. W. W. B.

393. *Small Distances Accurately Measured by Superposing Photographs of Star Fields.* **F. Henroteau.** (Roy. Astron. Soc. Canada, J. 14. pp. 363-364, Nov., 1920.)—With a wide-angle camera attached to the large equatorial at Ottawa Observatory photographs were obtained of fields surrounding 17 Vulpeculæ and 8 Cygni, portions of which are common to both. In trying to superpose the common portions a curious effect is produced, of which plates are given, and it is shown that the centres of the apparent spirals move quite a large amount when a very small môvement is given to one plate. It is claimed that under certain conditions the amount to be measured may easily be increased 100-fold, thus obtaining greater accuracy than that secured by an ordinary screw-micrometer. W. W. B.

394. *Cepheid Variable R S Orionis.* **F. Henroteau.** (Roy. Astron. Soc. Canada, J. 14. pp. 360-362, Nov., 1920.)—The author obtained photographic observations in 1911 at the Belgian Royal Observatory, using the focal method on thirteen plates, the diameters of the star images being repeatedly measured with a microscope. The resulting light-curve is compared with Münch's visual one, and shows a range of magnitude nearly twice as great. Each curve shows a deformation of the descending branch. W. W. B.

395. *Stellar Parallaxes Determined at Greenwich Royal Observatory.* (Roy. Astron. Soc., M.N. 81. pp. 32–36, Nov., 1920.)—This is the second instalment [see Abs. 1228 (1915)]. On resumption after the interruption caused by the war, the use of Kapteyn's method was discontinued, and the plates were developed as exposed. Thus it was no longer a question of comparing two sets of images on the same plate. A plan was adopted of taking one photograph of the field through the glass of the reversed plate, so that it can be placed in the micrometer film to film with the corresponding direct plate, with pairs of images adjusted to be within ½ mm. of each other, the auxiliary plate being uppermost. To reduce the increased error of measurement thus introduced, a ruled scale plate was substituted for the auxiliary plate. 49 parallax determinations are tabulated, the number of plates used for each varying from 10 to 26. W. W. B.

396. *Time and Temperature of Formation of a Stellar Cluster in a Homogeneous Nebula.* **A. Véronnet.** (Comptes Rendus, 171. pp. 707-709, Oct. 18, 1920.)—In continuation of previous work [see Abs. 1576 (1920)], dealing with the formation of a single star, the author considers the solar system as a sort of cluster condensing from a scattered nebula of 100,000 times its dimensions, and arrives at a temperature of 7850°, instead of 10,500°, obtained for a single body. He assumes a temperature of 6000° for the photosphere, and an increase of 1 deg. per 50 m. from there to the surface of the homogeneous nucleus, at a depth of from 50 to 100 km., the maximum internal temperature thus being

between 10,500° and 20,000°. Applying his formula to Jupiter and the earth he finds the extreme limits 3500° and 1200° respectively corresponding to that of 20,000° for the sun. He maintains that the temperature decreases throughout the evolution, denying the increase and decrease from "giant" to "dwarf" stages. [See Abs. 709 (1919).]
W. W. B.

397. *New Short-Period Variable.* **A. Danjon.** (Comptes Rendus, 171. pp. 901–903, Nov. 8, 1920.)—Having made a large number of photometric observations of the comparison stars observed with Nova Cygni, 1920, the author finds a new variable among them, *d* Cygni (19h. 48m. 37·3s. + 52° 47′ 11″ for 1920). It varies from 5·16 to 5·36 magnitude in a period of 1·0815 day, and is of β Lyræ type. The probable error of the period is less than two minutes. This is the fourth naked-eye star with this type of variability, but the observatory of Strasburg is unfortunately not equipped for the necessary spectroscopic investigation, so the author commends his discovery to others. W. W. B.

398. *Absorption Lines of N and O in Spectra of Nova Aquilæ III.* **F. E. Baxandall.** (Roy. Astron. Soc., M.N. 81. pp. 66–72, Nov., 1920.)—Questions have been raised as to the validity of the identity of certain lines in novæ, with N and O. The author is anticipating his full results in order to deal with this matter. The plates relied upon are principally those taken by J. S. Plaskett at the new Dominion Observatory in British Columbia and Table I gives a list of N and O identifications from one of his photographs taken on 1918 June 15. The pair of abnormal strong lines near 4060 is considered specially, and the variation of radial velocity on the assumption that they are nitrogen is shown to be no greater than accepted ranges for H. Comparison is also made for safety's sake with mean results of different observers. W. W. B.

399. *Light-Curves of Recent Novæ, with Notes on the General Features.* **I. Yamamotu.** (Kyoto Coll. Sci., Mem. 4. pp. 13–22, Sept., 1919.)—The author gives preliminary light-curves of Novæ Geminorum I and II, Nova Aurigæ, Nova Persei, Nova Lacertæ, and Nova Aquilæ, with all the separate sets of observations, and general deductions are drawn.

(1) Rapid decrease from maximum.
(2) More or less periodic fluctuations.
(3) Spectroscopic transformations B–F–Nova–Nebular–Planetary–Nebular–Wolf-Rayet type.
(4) Peculiarities of spectra, especially dark borders on the violet edge of bright bands.
(5) Very wide spectral lines.
(6) Prominence of H, He, Ca, Nb.
(7) Large relative radial velocities.
(8) Connection with suspected surrounding nebulosity.

From these observed data the author arrives at some physical meanings, *e.g.*, the rapid cooling suggests small mass. Analogy with similar behaviour of H, He, etc., lines in solar prominences suggests the outburst of novæ as possibly due to eruption, with a special explanation to lower the apparent motion of absorbing material. Other considerations point to conditions transcending any terrestrial experience. W. W. B.

400. *Hypothetical Parallaxes of 556 Visual Double Stars.* **J. Jackson** and **H. H. Furner.** (Roy. Astron. Soc., M.N. 81. pp. 2–31, Nov., 1920.)—The authors compute the limits of error introduced by the inclusion of double stars of whose orbits only a small arc has been covered by observation. The parallax $= a/[(m_1 + m_2)P^2]^{1/3}$ where a is the semi-axis major of the orbit, m_1 and m_2 are the masses of the components, and P is the period. From even a small arc the error in d^3/P^2 is shown to be reasonably small and the error in adopting a mean value for $m_1 + m_2$ is also small. There is therefore good ground for expecting the mean hypothetical parallax to be nearly correct. This is tested by comparison with trigonometrical and spectroscopic parallaxes, and deductions are drawn that the hypothetical parallaxes found in the paper are a little too small, especially among the nearer stars, and that the late-type stars which predominate in this class are less massive than the mean. The deduced solar motion is 19·13 km. per sec. in direction 273°·0 + 33°·8, which is in good accordance with Campbell's spectroscopic result. Frequency curves are given for absolute magnitude with different spectral types, generally confirming the results of Russell and Hertzsprung, but with some differences noted. In regard to distribution in space and the evolution of the stellar universe, no facts are disclosed hostile to Russell's theory, and a summary of conclusions is given, including facts outside the scope of the paper. The tabular matter includes all the stars used, giving the number in Burnham's general catalogue of double stars, the spectral type, magnitude, absolute magnitude, and hypothetical parallax. A further table gives weighted comparisons in cases where other determinations of parallax (trigonometrical or spectroscopic) are available. W. W. B.

401. *Radial Velocities of Eighteen Stars; Six New Binaries.* **A. Hnatek.** (Astrophys. J. 52. pp. 198–200, Oct., 1920.)—The values given are found from 45 spectrograms taken in 1913–17 with the Coudé spectrograph of the University Observatory, Vienna. Ten of the stars are spectroscopic binaries (12, 15k, 42, 50 Cassiopeiæ, 34ψ^2, 68, 71, + 62°·637, Draconis, + 65°·369 Camelopardi, 21 η Ursæ Minoris). The other eight stars are 16, 19, + 59°·2395, + 83°·104 Cephei, 73, + 73°·835 Draconis, 25 θ Ursæ Majoris and 23 δ Ursæ Minoris). The values found for the first two binaries are to be adopted in preference to those given previously by the author, and of the remaining eight, only two (50 Cassiopeiæ and + 65°·369 Camelopardi) had been previously declared binaries, so that six are new. W. W. B.

402. *Variable Bailey 33 in Cluster M5. Note on Barnard's Observations.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 81. pp. 74–83, Nov., 1920.)—The author recently suggested a change of period in this variable. An alternative suggestion was that one of the comparison stars might be variable. Barnard's observations supplied no proof of this, but an appeal to Mount Wilson for photographs has produced further comparisons, and the complete series is fully investigated by the author, whose conclusions are :—(1) Bailey 33 does show distinct changes of period in 1904 and 1914. (2) The comparison star (k in the list) varies in a period of 0·514770 day, a sharp fall of 0·25 mag. in 1·5 hours being followed by a general rise to maximum for 10 hours, the sharp fall being followed by a comparatively sharp rise to a second maximum. (3) The Mount Wilson plates do not cover the requisite times for full confirmation and more are

required. (4) They do suggest a rapid fluctuation in about 1-9th of the main period, which Barnard's observations do not contradict. Again more are required. W. W. B.

403. *Stellar Photography in Daytime.* **M. Hamy.** (Comptes Rendus, 171. pp. 691–695, Oct. 18, 1920.)—The colour of the sky has been shown to be due to scattering of sunlight [see Abs. 519 (1918)]. This scattering in a very clear sky, in which nothing is suspended but dust or vapour particles much smaller than a wave-length, is not constant through the spectrum, but varies inversely as the fourth power of the wave-length. The use of a monochromatic colour screen enables us to increase the contrast between the light of a star and of the neighbouring sky. An infra-red screen is, however, not yet available.

The author has experimented at the Observatory on Mt. Blanc, with special Lumière plates and a dark red screen. His method of testing the sky is to grade by means of a photometric wedge, the blackening of the film by the image of an electric filament, standardised by means of stars of 1st, 2nd, 3rd, etc., magnitude, and then with the same screen to photograph the day sky 90° from the sun, and compare the blackening. This method avoids the necessity of setting up an equatorial to experiment with the actual stars in the day time. He finds that the special plates with screen require 600 times the exposure of ordinary plates. Hence a first-magnitude star, to photograph which in the ordinary 13-in. Astrographic telescopes requires less than 1-30th sec., can be photographed with the special apparatus in less than 18 secs. The sky at Mt. Blanc took 32 minutes to cause the same amount of blackening, so the author computes that a 6th-magnitude star can be photographed there in the day time. The presence of ice crystals in the air prevented the application of the method near the sun. The author intends to pursue the subject further, experimenting with different localities to find the best sky conditions. W. W. B.

404. *Spectrum of Nova Aquilæ III in July* 1920. **A. Hansson** and **H. Jelstrup.** (Comptes Rendus, 171. pp. 1376–1378, Dec. 27, 1920.)—The star was about the 9th magnitude at the time when these two spectrograms were obtained at Meudon, with objective prism on 8-in. equatorial, adjusted for the violet, with rapid Wratten plates, sensitive to blue-violet, length of spectrograms 1 cm. with 3·7 mm. separation between H_β and H_γ. There is a continuous spectrum only from λ4000 to λ4800 and the intensity curve is given, with a list of wave-lengths of emission bands. The comparison star was Altair. The exposures were 2 hours on July 20 and 1 hour on July 21. The nebular lines have increased in intensity, the others have diminished. The broad bands of H and Nb are very nearly as wide as in July 1918, but no longer show any triple maxima. W. W. B.

405. *Spectroscopic and Magnitude Observations of Nova Cygni III,* 1920. **W. J. S. Lockyer** and **D. L. Edwards.** (Roy. Astron. Soc., M.N. 81. pp. 38-50, Nov., 1920.)—A plate shows twelve progressive spectra of the nova, and the observed magnitudes are tabulated from Aug. 22 to Oct. 9. The spectral changes are compared with the light-curve and the sequence is discussed. The main conclusions are :—(1) The light-curve shows an abrupt rise to maximum on Aug. 24, followed by a gradual decline with occasional secondary maxima. This decline

is about 5 times as speedy as that of Nova Persei or Nova Aquilæ. (2) During increase, nearly complete absorption spectrum like α Cygni, except for broad H and K and a few bright lines. (3) At maximum the only difference was that the lines were diffuse. (4) Successive changes to "typical nova spectrum," "4640," and nebular stages, the bright metallic lines persisting well into the "4640" stage. (5) Dark H lines show variable velocity towards the earth, varying from 330 km. per sec. on Aug. 22 to 900 km. on Aug. 26, gradually reducing to 460 km. by Sept. 19. (6) Width of bright H components varied nearly in the same way as the velocity in last section with maximum on Aug. 26. (7) On and after Aug. 25, the bright H lines were split into two parts by a central reversal. Till Sept. 6, the violet component of H_β was the stronger, but afterwards they became equal. The red component was always the stronger in H_γ, H_δ, and H_ϵ. (8) Comparison of previous spectrograms of novæ suggests that they all at or just before maximum show absorption spectra like α Cygni, and maintain the bright enhanced metallic lines till the "4640" stage. (9) On this basis the author suggests a method for discovering novæ in their early stages [see Abs. 1571 (1920)]. **W. J. Luyten.** (Roy. Astron. Soc., M.N. 81. pp. 61–65, Nov., 1920).—These observations were made at the Greenwich Royal Observatory, the photographs being obtained with the 26-in. refractor. Light-curves are given from visual and photographic observations, a rotating shutter and a diffraction grating being employed on the 26-in. telescope to reduce the magnitude of the nova in order to make it comparable with neighbouring stars. The period covered is Aug. 21 to Oct. 2. W. W. B.

406. *Magnitude of Nova Cygni* 1920, *Observed at Radcliffe Observatory, Oxford.* **A. A. Rambaut.** (Roy. Astron. Soc., M.N. 81. pp. 52–56, Nov., 1920.)—The observations were made at first with the naked eye and afterwards with opera-glasses and telescopes. From the detailed magnitude estimates, three phases are deduced after the maximum on Aug. 24:

(1) Rapid decline 0·15 mag. per day till Aug. 31.
(2) Slower steady fall 0·1 mag. per day till Oct. 18.
(3) Nearly stationary from Oct. 19, with tendency to rise at the end of the series (last date Nov. 11).

No marked fluctuations were recorded, but plotting the results shows slight oscillations with *suspected* period of 12 or 13 days.

Greenwich Magnitudes. (Roy. Astron. Soc., M.N. 81. p. 37, Nov., 1920.)—These magnitudes are from photographs taken with the Astrographic refractor at the Greenwich Royal Observatory from Aug. 22 to 29, using the stars α, β, and γ Ursæ Minoris for comparison. The aperture was stopped down to 7 in. and a diffraction grating placed in front of the objective in order to give smaller images and minimise the errors due to unequal exposures on nova and comparison stars. W. W. B.

LIGHT.

407. *Prism Astrolabe of New Type S.O.M.* **Claude** and **Driencourt.** (Comptes Rendus, 171. pp. 847–849, Nov. 2, 1920).—In order to meet the objections made to the ordinary form of prism astrolabe, such as the necessity of putting it together and dismounting it in the dark (three parts in three separate boxes), the number of adjustments, smallness and faintness of field and of eyepiece, the absence of a finder, etc., the authors have produced a new form for which they claim exemption from these defects. It is in one piece, of only half the height, with only one vertical axis, so that the level cannot get out of adjustment. It has a minimum number of adjustments, which cannot be far wrong, a brighter and larger field, with an eyepiece of twice the eye-aperture. The auto-collimation is quite simple, and so is the change of eyepiece. Other advantages are described, including the reduction of the weight by 60 %. W. W. B.

408. *Apparatus for Testing Focal Lengths.* **C. v. Hofe.** (Zeits. techn. Physik, 1. 9. pp. 191–197, 1920).—A description is given of two instruments, the first, an ocular-focometer, being designed for the rapid determination of focal lengths of eyepiece combinations, and the second for the comparison of the focal lengths of objectives. The chief interest lies in the diagrams and photographs, together with the descriptive matter. Those interested should consult the original paper. A. W.

409. *Photographic Representation of Solids (Stereophotographic Synthesis): Method and Apparatus.* **L. Lumière.** (Comptes Rendus, 171. pp. 891–896, Nov. 8, 1920.)—Describes a form of camera in which it is possible to obtain a photograph of all points in an object which lie in a single plane, this section plane being parallel to the plate of the camera. By the use of a number of successive photographs taken for parallel planes at small equal intervals, it is possible to obtain a reconstruction of the solid in space. The principle of the camera depends upon an optical arrangement in which points on one plane alone suffer no displacement when the plate and lens are moved by definite amounts (in a given ratio) in planes parallel to that under consideration. When an exposure is made, the lens and plate are caused to move in this manner, so that the only clear images resulting are those of points in the desired plane of the object. J. W. T. W.

410. *Absorption of Light; Width of Absorption Bands in Different Regions of the Spectrum.* **G. Ribaud.** (Comptes Rendus, 171. pp. 1134–1136, Dec. 6, 1920.)—This paper deals with the broad continuous regions of absorption shown by gases, liquids, and solids. After briefly indicating the experimental laws hitherto known, experiments are referred to which lead to the conclusion that for the same substance in different physical states, or for the same chemical group in different compounds, the maximum of the continuous region of absorption is more displaced towards the long wave-lengths the greater the value of the maximum absorption.

Other experiments have shown that at a given temperature, the damping in an absorption band only depends on the position of this band in the spectrum. In other words, if two bodies have an absorption band in the same region of the spectrum, the dampings, or what comes to the same thing, the widths of their bands, are the same. Numerous verifications of this principle have been made.

The *width* δ *of an absorption band*, which is solely a function of its position in the spectrum, increases continuously on going from the ultra-violet towards the infra-red, very nearly proportionally to the wave-length maximum. For $\lambda_m = 2700$ Å, $\delta = 420$ Å, and $\lambda_m/\delta = 6{\cdot}4$. For $\lambda_m = 5000$ Å, $\delta = 770$ Å, and $\lambda_m/\delta = 6{\cdot}5$. For $\lambda_m = 33{,}000$ Å, $\delta = 7200$ Å, and $\lambda_m/\delta = 4{\cdot}9$. It is interesting to note that for all the ultra-violet and visible bands studied the observed widths of the absorption bands furnish a damping coefficient r (defined by the relation $md^2x/dt^2 + mrdx/dt + m\omega_m^2 x = he$) very approximately equal to the frequency.

A. W.

411. *Ultra-Violet and Visible Transmission of Various Coloured Glasses.* **K. S. Gibson, E. P. T. Tyndall,** and **H. J. McNicholas.** (Bureau of Standards, Technol. Papers No. 148 [27 pp.], Washington, 1920.)—The paper summarises investigations on 87 samples of glass, mostly coloured. Spectral transmission curves extending from about 710 $\mu\mu$ throughout the visible and ultra-violet as far as any appreciable transmission is evident, are presented. The authors also give a chart connecting thickness of material and transmission. Among the uses to which such glasses may be put are ultra-violet signalling, railway signalling, improvement of visibility (both visual and photographic), eye-protection, selective filters. Photographic, photoelectric, and visual methods are described. Photographic determinations were made with the Hilger sector-photometer and a quartz spectrograph. The visual data were obtained mainly with the König-Martens spectrophotometer. In an appendix some particulars of precautions necessary in obtaining data on the ultra-violet region are given and some spectro-photographs showing the effect of various solutions are included. J. S. D.

412. *Measurement of Diffuse Reflection and a New Reflectometer.* **A. H. Taylor.** (Bureau of Standards, Bull. 16. pp. 421–436 [Sci. Papers No. 391], 1920. Illum. Eng., London, 13. pp. 265–269, Oct.–Dec., 1920. —Abstract.)—The author first presents a summary of previous methods of measuring the absolute reflecting powers of surfaces. Nutting's apparatus depended on the principle of infinite parallel planes, and was subject to various inaccuracies. Most of the other devices utilise the integrating sphere.

Apparatus.—The new reflectometer devised by the author utilises a sphere with whitened interior, a portion of which can be removed and the surface to be examined substituted. A narrow beam of light can be directed on to this area through an aperture in the sphere immediately opposite. The brightness photometer is directed towards the wall of the sphere through an aperture such that the line of view is at right angles to the beam of light. The positions of photometer and tube containing the light source are interchangeable. The beam of light can thus be directed either on to the wall of the sphere or the test surface, which latter occupies about 10 % of the total sphere area. A complete account

is given of the theory of the instrument which involves measurements of the average brightness of the sphere-wall with (*a*) the 10 % aperture uncovered and (*b*) with a test surface of a certain reflecting power substituted. Several alternative methods are suggested. The accuracy of the apparatus is tested by observations of a series of standard surfaces of graded reflecting power, obtained by mixing drawing ink and lamp-black with a fine cement. The reflecting power was obtained by two different methods—(1) using the reflectometer, and (2) by point-to-point measurements. Good agreement is recorded.

Results.—Tests on freshly prepared magnesium carbonate blocks gave values of reflecting power of 98·7–99·3 %, agreeing closely with the value ascertained by other observers. The testing of surfaces having some degree of polished reflection can also be made, the error arising from such reflection being in general less than 2 %. J. S. D.

413. *Some Phenomena of Laminar Diffraction Observed with Mica.* **P. N. Ghosh.** (Indian Assoc. for Cultivation of Science, Proc. 6. 1 and 2. pp. 51–65, 1920.)—In a previous paper [Abs. 347 (1920)] the author described and explained the colours shown by the striæ or laminar boundaries in mica when it is examined by the Foucault test. The present paper describes some observations on the microstructure of these laminar boundaries and of the various diffraction effects produced by them. The following are the principal results obtained. (1) The striæ appear resolved in the microscope into minute echelons or staircase structures, the number of steps varying from one to ten or fifteen for different striæ. The optical retardation due to any particular edge in the echelon is generally quite a small fraction of a wave-length. The edges are nevertheless clearly visible in the microscope as very sharp dark lines.

Asymmetry in distribution of colour of the fringes and method of exhibiting same.—(2) In consequence of the structure of the striæ, the laminar diffraction pattern observed even at a considerable distance from the mica shows distinct evidence of asymmetry in the distribution of intensity and colour of the fringes. A very delicate method of exhibiting this asymmetry is furnished by spectroscopic analysis of the laminar diffraction pattern, the dark bands due to interference running obliquely through the spectrum, and being much more clearly marked on one side of the pattern than on the other. (3) In the immediate neighbourhood of the striæ the diffraction phenomena as observed through a microscope are more complicated, the asymmetry being very marked, and a very large number of fringes may be observed. (4) The striæ scatter light through large angles, the light thus diffracted showing a marked asymmetry in its intensity on the two sides of the direction of the incident light, and also exhibiting both colour and polarisation. Photographs of the various effects are reproduced. A. W.

414. *Diffraction-Figures due to a Heliometer Objective.* **S. K. Mitra.** (Indian Assoc. for Cultivation of Science, Proc. 6. 1 and 2, pp. 1–18, 1920.)—Photographs of the diffraction pattern due to a heliometer objective, with relatively long exposures show that the pattern consists roughly of two sets of parabolas (with a common axis at right angles to the bright horizontal ray) branching in opposite directions. The fluctuations of intensity along the long bright ray that appears crossing the pattern decrease both relatively and absolutely at large angular deviations.

The author proposes a new geometrical theory by means of which the light intensity at any point in the focal plane is considered as due to the interference of two or three light-sources situated at definite points on the boundary. This is done by a simple transformation of the ordinary expression for the light vector taken as an integral over the surface of the aperture, into a line integral taken round the boundary, which latter is finally reduced to two or three sources, of proper phase and amplitude, situated on the boundary of the aperture. This method facilitates numerical computation of the light intensity for small as well as for very large angles of diffraction (the latter being almost impossible to obtain by the ordinary method), and gives results which are nearly as accurate as those obtained by the rigorous mathematical formulæ. It has also the additional advantage of enabling the form of the pattern to be readily determined for any desired area surrounding the focus, and the geometrical form thus deduced is in close agreement with that found experimentally. The author has made preliminary observations on the diffraction-figures due to apertures greater and less than a semicircle respectively, and has found that in these cases also the form of the pattern can be deduced from the above geometrical considerations.

J. W. T. W.

415. *Scattering of Light by Argon. Determination of Avogadro's Constant.* **J. Cabannes.** (Comptes Rendus, 171. pp. 852–853, Nov. 2, 1920.)—*Measurements* were made of the scattering of light by a mixture of 91 % argon, 8·7 % nitrogen, and 0·3 % oxygen. The author sought to determine the ratio R between the intensity of the light scattered laterally by 1 cm.^{3} of argon and the intensity of the incident beam. *Result.*—The result obtained for the above mixture was $R = (1{\cdot}34 \pm 0{\cdot}05) \times 10^{-8}$. The gas was at atmospheric pressure and a temperature of 27°.

Avogadro's constant.—The author finds that the polarisation of the light scattered laterally by argon is almost complete. This result differs from that previously obtained by Strutt [Abs. 41 (1919)]. If the polarisation is nearly complete, the molecules of argon can be compared to spherical particles, and Rayleigh's theory applied to them. This gives a result for Avogadro's constant of $(6{\cdot}90 \pm 0{\cdot}25) \times 10^{23}$. This value agrees with that found by Millikan ($6{\cdot}07 \times 10^{23}$) and by Perrin ($6{\cdot}85 \times 10^{23}$). [See Abs. 568 (1919), 1579 (1920).]

A. W.

416. *Interferometer Method for Determining Thickness of Quartz Etalons.* **A. Pérard.** (Comptes Rendus, 171. pp. 1131–1133, Dec. 6, 1920.)—The method employed to measure the thickness of the quartz blocks (which are intended for use in a re-comparison of the metric standard of length with wave-length standards) was very similar to the Michelson interferometer. Full details are given, with a table of the refractive indices of crystalline quartz for various wave-lengths between λ4360 and λ6440.

A. W.

417. *Relations between Colour of Light and Spectral Distribution of Light in the Stimulus.* **I. G. Priest.** (Optical Soc. of America, J. 4. pp. 388–401, Sept., 1920.)—Relative brightness of colours due to heterogeneous stimuli can be indicated by the ratios of the integrals of luminosity with respect to wave-length, and quality of colour is determined

by spectral distribution of light. However, many different spectral distributions may excite colours of the same quality. The general relations between colours due to various heterogeneous stimuli and the corresponding spectral distributions do not appear to have been formulated. The author accordingly investigates a series of colours which appear to be the same, or nearly the same, but correspond with markedly different spectral distributions. Luminosity curves of these various paints are presented, and the wave-length of the centre of gravity of each of these curves was determined. *Conclusion.*—From these data the conclusion is drawn that if two lights, however different in spectral distribution, excite colours of the same quality, the wave-lengths of their spectral distributions are coincident. This is confirmed by "monochromatic analysis," *i.e.*, by finding a type of spectral distribution which will excite colour of the same quality as another distribution. A relation is given for the wave-length of the centre of gravity of a mixture of homogeneous light and sunlight. J. S. D.

418. *An Examination of the Munsell Colour System.* **I. G. Priest, K. S. Gibson, H. J. McNicholas.** (Bureau of Standards, Technol. Paper, No. 167 [33 pp.], Washington, 1920.)—A system of colour-notation has been developed by A. H. Munsell and is now investigated. It is generally agreed that colours can be best defined in terms of three qualities, usually expressed as hue, purity, and brightness. In the Munsell colour-system a series of cards of graded neutral tints are provided, and the coefficient of reflection of each is indicated by a number. The series of cards includes neutral tints and also various colours. Fuller details are given in a descriptive colour-atlas. The report comprises a study of the diffuse reflection from certain of these cards, namely, nine neutral greys and three samples of red, yellow, green, blue and purple, a discussion of the Munsell colour-scale, and recommendations for improvements in the system. The results are indicated on a series of charts, whence it appears that the values assigned on the cards are remarkably consistent. However, the interpretation of the numbers indicated on the cards is liable to cause confusion. It is stated that 2 indicates a reflection of 20 % of sunlight, 3, 30 %, etc. Actually, owing to a misunderstanding, it is the *squares* of the Munsell values that are proportional to the reflection of sunlight.

It is recommended that in future the reflections of cards should form a geometric series or natural scale, in which the reflection coefficient of each card bears a constant ratio to the preceding one. As regards the end point of the scale, it appears desirable to make absolute 100 % reflection correspond with 10, and evaluate lower standards accordingly. Each colour should be specified physically by spectral reflection curves of the actual cards, by monochromatic analysis on the basis of an established standard white, and by its constants under prescribed conditions on the Arons chromoscope. Reflection should be specified with reference to average noon sunlight. In order to avoid further confusion of terms it is desirable to secure general agreement in nomenclature among experts. Steps in this direction are being taken by the Bureau of Standards and the Optical Society of America. J. S. D.

419. *Theoretical Aspects of Recent Optical Observations with respect to the Relativity Theory.* **M. v. Laue.** (Phys. Zeits. 21. pp. 659–662,

Dec. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—Section 1 deals with the calculation of the deflection of light by the sun, which depends on the hypothesis that light propagation is determined on the general theory of relativity by the geodetic null-lines of the universe. This hypothesis has not been proved, but deduced by analogy from the limited relativity theory. It is now established in the present paper. Section 2 deals with the theory of the displacement of the red lines. Hamel and Einstein took part in the discussion. H. H. Ho.

420. *Defining the Annealing Temperature of Glass.* **F. Weidert** and **G. Berndt.** (Zeits. techn. Physik, 1. 2. pp. 51–58, 1920.)—Describes a method of defining the annealing temperature of a glass by heating a 25-mm. cube half-embedded in kieselguhr with one diagonal vertical. The temperature at which, after a given period, the cube shows the first traces of settling is termed the deformation temperature and is proposed as an indication of the annealing temperature. The deformation temperatures of various types of glass are tabulated in the paper, and the results are compared with those obtained by the cohesion-temperature and the softening temperature methods, a full description of both of these being given in the first part of the paper. J. W. T. W.

421. *Electric Dichroism of Fumes and the Dichroism of Diffraction Meshworks.* **S. Procopiu.** (Comptes Rendus, 171. pp. 1055-1058, Nov. 29, 1920.)—The author has previously shown [see Abs. 1585 (1920)] that the dichroism and birefraction of the fumes of ammonium chloride have a different evolution which may be attributed to the fact that dichroism depends on the magnitude of the particles. Experiments are now described which show that a dichroism is attached to the refraction of the particles. There are fumes which possess the dichroism without any trace of birefraction. Thus the fumes of essence of turpentine and those produced by burning magnesium show a positive dichroism of about half a degree for a potential of 2000 volts. The fumes of tobacco, phosphoric anhydride, the vapours of iodine and naphthaline show nothing. If dichroism is due to the arrangement in lines of the particles in the electric field, the same phenomena ought naturally to be presented with a diffraction meshwork. This is confirmed by experiment. A. E. G

422. *Photochemical Investigations of the Photographic Plate; New Equation for the Photochemical Law of the Silver-Halide Grain.* **R. E. Slade** and **G. I. Higson.** (Roy. Soc., Proc. 98. pp. 154-170, Nov. 3, 1920.)—Preliminary experiments have shown that the grain or crystal of silver halide is the photochemical unit in the gelatine dry-plate. A theory of the photographic plate can only be built up on a knowledge of the photochemical behaviour of the single grain of silver halide. The photochemical law of the silver halide grain is therefore made the subject of the present investigation. The blackening obtained on development of a photographic plate which has been exposed to light of a given intensity for a given time is determined by the following factors :—(i) The photochemical law of the silver halide grain, that is, the law determining the relation between P, the probability of a single grain being made developable in unit time, and t, the time of exposure, and I, the intensity of light to which the grain is exposed, *i.e.*, the form of the equation $P = f(I, t)$.

(ii) If the grains are not all the same in size and quality, there will be a law for each set of identical grains. (iii) If the silver halide absorbs actinic light the intensity of such light will fall off as it passes through the coating on the plate, so that the back layers of the silver bromide particles will be exposed to much weaker light than the front layers. The light gradient through the film will depend on (*a*) absorption of light by the silver bromide, (*b*) the relative refractive indices of the grains and of the gelatine which determine reflection, (*c*) the closeness of packing of the grains. (iv) Development consists in reducing to metallic silver, either wholly or partially, those grains which have been made developable by light. Since different developers act at different rates (also varying with the temperature) and diffuse at different rates into the gelatine layer, and as the state of dispersion of the silver formed varies to some extent with the developer used, the blackening must be affected by the developer. But it has been shown by Hurter and Driffield, Sheppard and Mees, and others that for a given plate and a given developer the photometric density is proportional to the amount of metallic silver in the film.

In the present experiments factors (ii), (iii), and (iv) are eliminated, *i.e.*, a method is devised whereby the law of the photochemical behaviour of these grains can be investigated, free from the disturbing effects of development, etc., which occur in the photographic plate itself. From the experimental results obtained a formula is deduced, which shows the relation between the behaviour of the silver halide grains, the light intensity to which they have been exposed, and the time of exposure. The results show that it is impossible for the mechanism of the process to be the absorption of light in discrete quanta, and that a given amount of light-energy has a greater effect photographically when concentrated into a short range of wave-lengths than when it is distributed over a large range. [See also Abs. 354 (1920).] A. E. G.

423. *Measurement of Graininess in Photographic Deposits: New Method Developed.* **L. A. Jones** and **N. Deisch.** (Eastman Kodak Co.'s Research Lab., Comm. No. 99. Frank. Inst., J. 190. pp. 657–683, Nov., 1920.)—In this paper the term "graininess" is used to designate that effect of inhomogeneity exhibited by the photographic deposits which is due to the presence of clumps of silver particles. The grainy appearance, which can be observed by the unaided eye, is due to further agglomeration of these aggregates and should be referred to as graininess of the second order. It is evident, therefore, that there are three phases in the non-homogeneity of a photographic deposit—(*a*) graininess due to the existence of the individual particles of silver, (*b*) graininess due to clumping of these particles, and (*c*) graininess due to the agglomeration of the clumps. It should be understood that these phases are not separated by any distinct line of demarcation, but merge by imperceptible gradations into each other. Graininess in reality is a subjective factor, and may be defined as the sensation or impression of non-uniformity in a photographic deposit, produced upon the consciousness of the observer of when such a deposit is viewed. This impression is the result not only of the size of the grains of which the deposit is composed, but also of the distribution and arrangement in groupings of various kinds. Many other investigations on the general subject of grain have been made, but no attempt is here made to give a complete bibliography of this literature. The standpoint from which this subject is approached in the present

paper is quite different from that of previous investigators, and the references given are mentioned in order to emphasise the difference between the points of view and also because of the interest attached to a comparison of the results of investigations on "grain" with those of this paper on "graininess." The only method for the determination of graininess at the time this work was undertaken was entirely qualitative in character. This consisted of the preparation of a series of prints made at a fixed degree of magnification from the positive under consideration. These were examined by a number of observers, and judgments rendered as to the relative graininess of the various prints. By averaging the individual opinions, final decision as to the proper order of arrangement in the series was obtained. Such a method, while giving some information as to the graininess characteristics, is not quantitative and is not at all satisfactory. Another method suggested and applied to a certain extent in this work consists in placing a mesh grating over the density to be examined and by observing this under a microscope, counting the number of groups of grains that fall under several of the openings of the grating. The average number of groups per unit area was then considered as a specification of the graininess. There is no reason, however, to suppose that graininess is proportional to the number of groups, it being more probable that this subjective impression is some complicated function of other factors such as the size and distribution of the grain aggregates. The possibility of utilising the ratio of the specular to the diffuse density of a photographic deposit was also considered.

After careful consideration a method based on a principle more closely parallel with the actual conditions existing in the observation of grainy photographic deposits appeared to give greater promise. The fundamental assumption upon which this method is based is that the graininess of a deposit is directly proportional to the distance at which the appearance of graininess becomes just imperceptible, provided that all other factors upon which depend the ability of the eye to distinguish lack of homogeneity are constant. In order that such a method be satisfactory, it is necessary to control the conditions of observation so that the results obtained shall depend upon only the variations in the photographic deposits considered. It is thought that in the method developed in this investigation the influence of all variable factors that operate to invalidate the results have been very largely eliminated, and that graininess has been expressed in terms of an easily reproducible standard. The apparatus employed is described and illustrated. Previous investigations have shown that the size of the silver grain is almost independent of the composition of the reducer. The curves here given show, however, that there is a very appreciable difference in the graininess produced by different developing agents. Graininess then is not altogether a function of grain size, which again emphasises the distinction between grain and graininess. These results also show that rapidity of development does not necessarily conduce to low graininess. Development goes on faster at higher temperatures without reduction in graininess. An extreme case is presented by paraphenylenediamine in solution with sodium sulphite alone, which acts very slowly and produces low graininess. An addition of an alkali increases the developing action of this developer enormously, but at the same time increases graininess. The explanation in this case is that the character of the development has been changed, presumably from a type of physical development to a typical chemical development. But in chemical develop-

ment itself, though increasing the concentration of alkali may be said generally to increase the speed of development and at the same time to cause a decrease in graininess, in this case also the graininess does not appear to be a function of the speed of development, but rather of some property intimately related with the specific alkali employed. A. E. G.

424. *Strains in Unannealed Glass.* **J. Salpeter.** (Zeits. techn. Physik, 1. 10. pp. 221–224, 1920.)—This paper gives further theoretical treatment of the case of a quickly cooled sphere of glass dealt with in a previous paper [Abs. 1359 (1920)]. A. W.

425. *Effect of Polarised Light on Light-Sensitive Substances.* **F. Weigert.** (Ann. d. Physik, 63. 8. pp. 681–725, Dec. 10, 1920.)—A continuation of previous work [Abs. 106 and 570 (1920)]. Improvements were made in the method of investigation of the effect of plane-polarised light on light-sensitive layers, and the method was specially applied to the changes occurring in photo-chloride layers in gelatine. The effect of circularly-polarised light was found to be similar to that of ordinary light. By comparison of the effects of plane-polarised and circularly-polarised light it was found that with the same intensity of illumination different shades of colour were obtained in the two cases, and these were visible to the naked eye. An arrangement is described for observing a transverse effect perpendicular to the direction of illumination. By these observations it was found that the light-sensitive layer becomes dichroic and anisotropic only if the electric vector of the exciting beam has a component in the plane of the layer. The optic axis of the anisotropic structure lies in the direction of the electric vector. Calling this direction the *e*-direction and that perpendicular to it the *m*-direction, the vibrations in the extraordinary ray are in the *e*-direction. Using coloured plane-polarised light, some colours gave a normal or positive dichroic effect, while others, especially in the blue, gave an inverse or negative dichroism.

Quantitative Measurements of Dichrosim by New Method.—Quantitative measurements were made of the dichroism by a new dichrometric method based on the half-shadow principle.

Connection Between Dichroism and Double Refraction.—The variation of double refraction with the duration of exposure was measured by means of a compensator. It was found to be different for different colours, and *Babinet's law* relating to the connection between dichroism and double refraction was *only found to hold for* the colours *red and blue.* A. W.

426. *Modification of Metallic Spark-Spectra by the Gas Medium.* **B. de la Roche.** (Bull. Soc. Chim. 25. pp. 305–309, June, 1919.)—The spark spectra in air or oxygen are very similar to those in nitrous oxide, CO_2, SO_2, even in intensity, and are similarly influenced by the introduction of self-induction into the circuit. The spectra may be very different in reducing gases, hydrogen, coal gas. This shows in the spectra of electrodes of Te, Mo, Ni, W, Sb, Sn, less so in those of Cu, Ag, Au, and not at all with Zn, Cl. Self-induction weakens these spectra in reducing media. H. B.

427. *Determination of Tertiary Normals in the Arc Spectrum of Iron.* **S[ophie] Hoeltzenbein.** (Zeits. wiss. Phot., 16. pp. 225–251, April,

1917.)—With the aid of a concave grating of 4 m. radius and 3960 lines/cm. the author under Konen, takes measurements, probably accurate within 0·001 A.U., of various ranges from 5568 down to 2987 in the 3rd, 4th, and 5th order spectra. The paper is largely tabular. Comparisons are made with the figures of Kayser, Burns, Gale and Adams, and of St. John and Ware, with special regard to tertiary lines suitable as normals. The divergencies found show the need of further measurements before a selection of normals is made. H. B.

428. *Triboluminescence of Uranium Compounds.* **J. A. Siemssen.** (Chemiker Zeitung. 43. p. 267, May 13, 1919.)—Ivanov and Andrews having had explosions while working with uranyl acetate, the author resumed his researches on various uranium salts, either purchased or prepared by him and analysed. Triboluminescence and fluorescence were generally observed, but not any tendency to explosions, which might be due to some labile nitrogen oxide. None of the specimens discoloured the glass bottles (lead glass) in which some had been kept for four years. H. B.

429. *Maximum Limit of Temperature.* **W. Jankowsky.** (Zeits. Elektrochem, 25. pp. 325–328, Oct. 1, 1919.)—The study of heat reactions at moderate temperatures suggests that most of the heat is developed by the conversion of potential energy into heat. On that view there should be both a lower and an upper limit of temperature. Absolute zero is the temperature at which the energy content of the substance is entirely potential, and its conversion into heat impossible. The maximum limit of temperature is reached when the energy content consists entirely of heat and cannot be converted into potential energy. Heat changes are possible between these limits, which are reached asymptotically. H. B.

430. *Identification of the Carriers for Emission Band-Spectra; the so-called Water-Vapour Spectrum.* **A. Reis.** (Phys. Zeits. 21. pp. 601–602, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—This paper gives a brief account of a method for identifying the carriers in emission band-spectra. The method was applied to the so-called water-vapour spectrum, and the conclusion is drawn that the spectrum has nothing to do with water-vapour, but is due to some substance whose presence in the flame is closely connected with that of O_2. Stark and Steubing put forward the view that the the spectrum is probably due to O_2 [see Abs. 599 (1913)]. A. W.

431. *Constant Light-Source with Continuous Ultra-Violet Spectrum.* **G. Gehlhoff.** (Zeits. techn. Physik, 1. 10. pp. 224–227, 1920.)—It was found that with an ordinary half-watt lamp of 7000 candle-power there was an appreciable transmission of ultra-violet light even through a lead-glass envelope. Experiments on the spectral distribution of energy from a band or spiral of tantalum at various temperatures from 2200° abs. to 3070° brought out some interesting facts, which are illustrated by tables and graphs. The lamp finally adopted has a diam. of about 10 cm., with a tungsten spiral or tantalum band as the light source; it is filled with nitrogen or argon, and the temperature raised above that normally used in half-watt lamps. The lamp is

provided with a quartz window. When examined spectroscopically the light from the lamp is found to give a continuous ultra-violet spectrum, which can be used for many purposes, particularly for the investigation of absorption spectra. The life of the lamp naturally depends on the degree of overheating of the filament. Photographs are given of the spectra of (1) a quartz mercury lamp, (2) the new lamp, (3) and (4) absorption spectra of nitrates of didymium and samarium, (5) and (6) silver filters of different thicknesses, (7) and (8) absorption spectra of NO_2 of different densities. A. W.

432. *Deduction of Rydberg's Law from the Quantum Theory of Spectral Emission.* **S. N. Basu.** (Phil. Mag. 40. pp. 619–627, Nov., 1920.)—In this paper an attempt is made to deduce the laws of regularity in the spectral series of elements on the basis of Bohr's quantum theory of spectral emission. Starting from Sommerfeld's assumption that the ordinary line-spectra of elements are due to the vibration of one outer electron (the valency electron), it is shown that the field of the nucleus and the remaining $(n - 1)$ electrons may be represented by the potential $V = -e^2/r \pm eL\cos\theta/r^2$; *i.e.*, the field due to a single charge plus a doublet of strength L. The axis of the doublet is variable, but the emission is supposed to take place so quickly that during the short time in which emission occurs the axis does not appreciably change.

The quanta conditions are applied according to Sommerfeld's rule, $nh = \int p_i dq_i$, and the energy of the system is reduced to the quanta numbers. The energy comes out in the form $W = -Nh/(n + n_3 + z)^2$, where n_3 is the radial quantum, n the azimuthal quantum, and z is given by an equation of the sixth degree, involving only n, and is therefore a function of n only.

It is next shown that if, in accordance with Sommerfeld's principle, we assume $n = 1$ for the s-orbits, $n = 2$ for the p-orbits, $n = 3$ for the d-orbits, and $n = 4$ for the b-orbits, then, with a simple assumption, we obtain a single value for the energy of the s-orbits, a double value for the energy in the p-orbit, and a treble value for the d-orbit. Then applying Bohr's law $h\nu = W_n - W_{n'}$, we arrive at Rydberg's laws of the regularity in spectral series, in the case of the alkali metals. Exact calculations are not attempted on account of the uncertainty of the value of L; but it is shown that the values of s, (p_1, p_2), (d_1, d_2, d_3) progressively decrease, as is actually the case. If the value of L be supposed to vary with n_3, the radial quantum, then probably the calculations given would lead to Ritz's law. A. W.

433. *Spectral Laws; the Neon Spectrum.* **A. Sommerfeld.** (Ann. d. Physik, 63. 3. pp. 221–263, Oct. 7, 1920.)—This paper discusses various general spectral laws and particularly the law of magneto-optic dispersion. The various sections deal with (1) the permanence of multiplicities, (2) the principle of selection and its effect on line structure, (3) spectroscopic displacement laws, (4) Rydberg's valency law, (5) the law of magneto-optic dispersion. The last section is treated at some length, special reference being made to the spectrum of neon. A. W.

434. *Spectrum of Neon: Discussion of the Different Series.* **F. Paschen.** (Ann. d. Physik, 63. 3. pp. 201–220, Oct. 7, 1920.)—A continuation of previous work [Abs. 223 (1920)]. The present paper gives

a full discussion of the different series in the neon spectrum. The lines observed are arranged in 4 principal series, 4 first subordinate series, and 2 second subordinate series, which are shown to be related to one another. The limits of the series which are obtained by combinations of a set of term sequences, have with respect to the limits of analogous combined series obtained from related sets, a constant difference of wave-number of 782 cm.$^{-1}$, which is independent of the kind of series considered. This modification of the combination principle follows when the limits of all series are calculated from the Ritz formula.
A. W.

435. *Regularities in the Neon Spectrum.* **W. Grotrian.** (Phys. Zeits. 21. pp. 638–643, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—Paschen has given measurements of about 800 lines of the neon spectrum [Abs. 223 (1920)]. The present paper discusses the arrangement of these lines in series, and also the connections existing between the different series. [See preceding Abstract.] A. W.

436. *Emission and Absorption Spectra of Chlorine.* **M. Kimura** and **M. Fukuda.** (Kyoto Coll. Sci., Mem. 4. pp. 155–158, June, 1920.)—The emission and absorption band spectra of chlorine vapour were studied with a grating spectrograph of moderate dispersion. It was found that they are not exactly complementary, but chlorine emits light strongly in the region where the vapour absorbs light most strongly. A vacuum discharge tube was used for the emission spectrum work, and consisted of a tube about 20 cm. long with one end blown into a thin bulb, and provided with two side tubes containing sufficient pure and well-dried NaCl to just cover the Pt wires sealed through the ends of the tubes. The discharge tube was connected to a pump throughout the experiments.
A. W.

437. *Zeeman-Effect for Chlorine Lines.* **M. Kimura** and **M. Fukuda.** (Kyoto Coll. Sci., Mem. 4. pp. 159–161, June, 1920.)—The discharge tube used in these experiments had a capillary portion and was provided with a large bulb to reduce changes of gas pressure brought out by the discharge. In other respects it was similar to that used in the earlier work on the chlorine spectrum [see preceding Abs.]. The Zeeman-effect was studied for 9 single lines in the region λ4780 to λ5400. All these lines, with the exception of λ4786 were found to give magnetic triplets of wider specific separations than that of a normal triplet, but the separations bear simple numerical relations to that of a normal triplet. Certain other lines were found to be complex, and these will be discussed in a subsequent paper. A. W.

438. *Sensitive Spectral Lines; Ultimate Lines in the Spectra of 83 Elements.* **A. de Gramont.** (Comptes Rendus, 171. pp. 1106–1109, Dec. 6, 1920. Chem. News, 122. pp. 58–59, Feb. 4, 1921.)—The arrangements employed in the work here described were the same as used for determining the ultimate lines in the spectrum of titanium [Abs. 370 (1918)]. The present paper gives the ultimate lines in the dissociation spectra of 83 elements. The results are presented in tabular form. One column gives the ultimate lines observed visually, a second column the

ultimate lines obtained when using a "crown uviol" spectrograph, including lines from λ4800 down to λ3170, and a third column gives lines below λ3170 obtained with a quartz spectrograph. A. W.

439. *Spark Spectra of Mercury, Copper, Zinc, and Thallium in the Extreme Ultra-Violet.* **L.** and **E. Bloch.** (Comptes Rendus, 171. pp. 909–912, Nov. 8, 1920.)—Wave-length tables are given of 36 new mercury lines, all of which have small intensity, in the region between λ1640 and λ1400. Lyman's results for the more intense lines in this region are included. The measurements were made on a prism spectrograph, amalgams of cadmium and sodium being used as electrodes. Wave-length tables for copper between λ1785 and λ1540 show 18 new lines below λ1660, some of which are of considerable intensity. Within the range λ1840 to λ1440 twelve new lines of zinc and 13 new lines of thallium are recorded. Previously observed lines of all four metals in the regions studied have been re-measured. A. W.

440. *Effect of an Electric Field on the Rotation Spectrum; Formulæ Obtained Applied to HCl.* **G. Hettner.** (Zeits. f. Physik, 2. 4. pp. 349–360, 1920.)—If a gas molecule possesses an electric moment, its rotation must be affected by an external electric field. This rotation of the gas molecule gives rise to the rotation spectrum in the long-wave infra red, and to the fine structure of the absorption bands found in the short-wave infra red. It is therefore possible that an electric field will affect the lines of this spectral region. The present paper discusses this effect from the standpoint of Bohr's theory; the calculation based on the second quantum theory of Planck will be given in a subsequent paper. Formulæ are obtained which show that the effect of an electric field consists in splitting up and separating the lines. Application of the formulæ is made to the case of HCl. A. W.

441. *Excitation of Mercury Lines.* **R. Seeliger.** (Zeits. f. Physik, 2. 4. pp. 405–414, 1920.)—Improvements were made in the glow discharge method [Abs. 1540 (1919)] and a number of experiments carried out on the spectrum of mercury. Differences in the excitation conditions for the various series are noted and discussed. Empirical rules may be derived from the results, but measurements of the intensity ratios of the mercury lines in the glow discharge at various partial pressures will be necessary to establish a satisfactory theory. [See Abs. 1317 (1920).] A. W.

442. *Spark Spectra in the Extreme Ultra-Violet: Wave-Lengths of Lines of Sb, As, Bi, and Sn.* **L.** and **E. Bloch.** (Comptes Rendus, 171. pp. 709–711, Oct. 18, 1920.)—A description has previously been given of the fluorite spectrograph used, and new lines in the Schumann region have been given for Cd, Bi, Ni, and Ag [Abs. 558 (1920)]. The present paper gives tables of wave-lengths of lines in the spark spectra of Sb, As, Bi, and Sn between λ1850 and λ1400. A. W.

443. *Theory of Band Spectra; Iodine Fluorescence Spectrum.* **W. Lenz.** (Phys. Zeits. 21. pp. 691–694, Dec. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—A theoretical treatment of the effect of temperature on the intensities of

the lines of band spectra, with special reference to the fluorescence spectrum of iodine. [See Abs. 574 and 1071 (1920).] A. W.

444. *Broadening of the Mercury Line λ2537 ; Influence of H, N, CO_2.* **C. Füchtbauer** and **G. Joos.** (Phys. Zeits. 21. pp. 694–699 ; Disc., 699, Dec. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml. Nauheim, Sept., 1920.)—A description is given of the effect of different gases in broadening the mercury line λ2537. A cadmium spark in air was used as the source of light, a quartz lens being employed to focus the light in the middle of the absorption tube, and a second quartz lens to focus the light on the slit of a quartz spectrograph. The absorption tube was connected to a manometer, and a side tube containing mercury could be heated by a heating coil to give a determinate vapour pressure of mercury in the absorption tube. Hydrogen, nitrogen, and carbon dioxide were used in the absorption tube at pressures of 10 atmos. and 25 atmos. If $n\chi$ is the absorption coefficient at the place of max. absorption, and the values of the respective quantities for the same vapour pressure of mercury, but different pressures P_1 and P_2 of the gas used, be denoted by the suffixes 1 and 2, the exponent x in the formula $(n\chi)_1/(n\chi)_2 = (P_2/P_1)^x$ was determined for each of the gases at the pressures 10 and 25 atmos. For CO_2 the value of x was found to be unity, within the limits of error, so that $n\chi$ is in this case inversely proportional to the pressure of the broadening gas.

Results.—The value of x for nitrogen was found to be approximately 0·5 and for hydrogen 0·4, but though the broadening in these gases is small, good agreement was obtained between different sets of observations. [See Abs. 229 and 230 (1914).] A. W.

445. *Series Spectra of the Elements.* **N. Bohr.** (Zeits. f. Physik, 2. 4. pp. 423–469, 1920.)—A general review of the present position of the theory of atomic structure and the spectra of the elements. The nuclear theory of atomic structure and the quantum theory of radiation are considered, in preparation for the author's theory of the spectrum of hydrogen and the lighter elements. The fields of force inside hypothetical atoms are discussed in relation to this problem. A short abstract of the paper is not possible; the original should be consulted. A. B. W.

446. *Excitation of Mercury Spectral Lines.* **C. Füchtbauer.** (Phys. Zeits. 21. pp. 635–638, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—Describes experiments on the excitation of mercury lines by concentrated radiation from a mercury lamp of special construction on mercury vapour contained in a separate tube. The lamp consisted of two concentric tubes 15 cm. in length and sealed at the ends so as to enclose an annular space. Two side tubes were sealed into the outer tube, and these contained mercury and carried the terminals. Outside the double tube was a third tube filled with mercury, which served as a cylindrical mirror to concentrate the light from the discharge through the annular space on to a tube passing through the centre of the discharge tube. This central tube was provided with plane-parallel end pieces and a side tube containing a small quantity of mercury. By heating the mercury any desired vapour density of mercury could be obtained. The whole of the apparatus was constructed of quartz glass. Experiments with this

apparatus showed that the spectrum of the light given out by the Hg vapour in the central tube included not only the two "resonance" lines $\lambda 2537$ and $\lambda 1849$, but also, from the green onwards, all the first members of the series of single lines and of the triplet system. Moreover, the lines were very strong. Various uses are suggested for the apparatus, and the results are discussed. A. W.

447. *Mass-Spectra of Chemical Elements.* II. (*B, F, Si, P, S, As, Br*). **F. W. Aston.** (Phil. Mag. 40. pp. 628–634, Nov., 1920.)—This paper deals with the mass-spectra of B, F, Si, P, S, As, and Br. The apparatus and method employed were the same as used in previous work [Abs. 994 (1920)]. Boron (at. wt. 11·90) has at least two isotopes 10 and 11, and the evidence from various experiments is against the presence of a third isotope. Fluorine (at. wt. 19·00) was found to be a simple substance, as its atomic weight suggests. Phosphorus (at. wt. 31·04), arsenic (at. wt. 74·96), and sulphur (at. wt. 32·06) are also apparently simple substances. Silicon (at. wt. 28·3) has a predominant constituent 28 and another 29, with probably no others. Bromine (at. wt. 79·92) consists of a mixture of two isotopes in practically equal proportions at 79 and 81. A faint pair of lines at 80 and 82 are the expected lines of the two corresponding hydrobromic acids. The same difficulties as experienced previously with chlorine prevent the attainment of absolute certainty in determining the composition of bromine, or indeed that of any element capable of forming hydrogen compounds. Some anomalous fractional lines are mentioned and their possible origin discussed. The atomic weights of all the elements dealt with conform to the whole-number rule. Photographs are given of the apparatus used and of a number of mass-spectra. A. W.

448. *Effect of an Electric Field on Spectral Lines; Methods of Observing the Stark-Effect.* **F. Tuczek** and **W. Heuck.** (Ann. d. Physik, 63. 8. pp. 766–772, Dec. 10, 1920.)—A discussion of various methods of observing the Stark-effect. It is concluded that in the canal-ray method it is advantageous to connect the auxiliary electrode permanently to the kathode, a single current strength being thereby obtained. With both the canal-ray method and the method of the first kathode layer, using a variable potential and an inductance, observations can be made which agree with those at uniform potential. With a Gundelachs gas discharge-tube good results can be obtained, but work with this tube is difficult. More success is obtained with this method if a glowing-kathode valve tube is used. A. W.

449. *Light-Electric Phenomena with Zinc Sulphides.* **B. Gudden** and **R. Pohl.** (Zeits. f. Physik, 2. 2. pp. 181–191, 1920.)—When mixed with various metals, zinc sulphides exhibit in the light a considerable increase in electrical conductivity. With low strengths of field, for instance, about 1000 volts per cm., the phenomenon shows the same spectral distribution as the normal photo-effect, that is, essentially a continuous rise with increasing frequency. For high strengths of field, namely about 10,000 volts per cm., the course of the spectral distribution is as if on the normal photo-effect were superposed a strongly preponderating selective effect; the positions of this selective maximum have been determined for various added metals. The exciting cause of this

conductivity in the light is the same as that of the increase of the dielectric constant, yet the two phenomena are independent of one another. T. H. P.

450. *Enhancement of Phosphorescence by Electric Fields.* **B. Gudden** and **R. Pohl.** (Zeits. f. Physik, 2. 2. pp. 192–196, 1920.)—The excitation of phosphors, for which heating and illumination have been employed, may also be effected by powerful electric fields. A number of zinc sulphide phosphors have been examined, and it has been found that a short-lived illumination is produced by applying a field of about 3000 volts per cm., while a constant field of 15,000 volts per cm. gives rise to illumination exhibiting some persistence. T. H. P.

451. *Phosphorescence of Calcium Sulphide: Conductivity Variations in the Condition when Phosphorescence has been Destroyed.* **P. Vaillant.** (Comptes Rendus, 171. pp. 713–714, Oct. 18, 1920.)—This paper describes in detail the variations in the conductivity of calcium sulphide when exposed to light, all trace of phosphorescence having previously been destroyed by heating to a suitable temperature. The conductivity at first is very small. When exposed to diffused sunlight the conductivity increases for about 2¼ hours, when it attains a maximum; beyond this the conductivity slowly decreases with the time of exposure. A curious effect is obtained when, after a prolonged exposure, the calcium sulphide is placed in a constant-temperature dark room. The conductivity increases then rapidly, attains a maximum (much greater than the excitation maximum) after several hours, and then decreases very slowly. A. W.

452. *Relative Positions and Intensities of Lines in X-ray Spectra.* **W. Duane** and **R. A. Patterson.** (Nat. Acad. Sci., Proc. 6. pp. 518–527, Sept., 1920.)—A critical discussion of the work of the following scientists:—Siegbahn and Friman, de Broglie, Webster and Clark, Sommerfeld, Overn, Bohr, and the authors. The paper does not permit of a concise abstract. A. B. W.

453. *Absorption Lines in the Röntgen Spectrum: L-series of Nd and K-series of Mn.* **G. Hertz.** (Phys. Zeits. 21. pp. 630–631; Disc., 631–632, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—Investigation of the long-wave absorption limits of the L-series of neodymium, and of the K-series of manganese, using very thin absorbing layers, showed that both gave a sharp absorption line within which the absorption is total; so it is concluded that selective absorption gives rise in the Röntgen spectrum, just as in the case of light, to sharp absorption lines in which the absorption is many times that of the continuous absorption in the neighbouring part of the spectrum. [See Abs. 902 (1919).] A. W.

454. *Bragg's Reflection Law for Röntgen Rays.* **P. P. Ewald.** (Phys. Zeits. 21. pp. 617–619, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—A theoretical treatment which shows that deviations from Bragg's law of reflection for Röntgen rays must arise on account of phase differences brought about by passage of the rays through the individual planes of the crystal network. A. W.

455. *X-ray Spectra.* (Phys. Soc., Proc. 33. pp. 1–12, Dec., 1920. Discussion.)—**W. H. Bragg,** opening the discussion, dealt with the X-ray spectrometer as an instrument of precision, discussing the nature of the measurements that can be made with it. He compared the possibilities of photographic and ionisation spectrometers, dealing with the accuracy obtainable by these instruments. The ionisation spectrometer gives observable results more quickly and is far more reliable for the purpose of comparing intensities of lines. The ionisation method has been used with excellent results by Duane, Webster, Compton, and others in America; whilst Dershem, Overn, de Broglie, Hull, and others have used photography. Reference is also made to the work of Wagner, Debye, Leighton, and others. The recent developments in X-ray research were briefly reviewed and the theoretical bearing of the results discussed from the standpoint of atomic structure. **C. G. Darwin** gave an account of the theory underlying the production of X-ray spectra, the work of Bohr and Sommerfeld receiving special consideration. **E. A. Owen** referred to the four kinds of frequencies of vibrations associated with X-ray spectra. In the case of the K-series there is or are (1) several emission frequencies, (2) one frequency such that when multiplied by Planck's constant the product is equal to the minimum of energy which the electron in the X-ray tube must have to produce that emission series, (3) one critical absorption frequency, and (4) one critical ionisation frequency. **A. O. Rankine** referred to the value to teachers of these coordinated accounts of a particular branch of Physics. A. B. W.

456. *Spectral Investigations of Röntgen Rays; the Continuous Röntgen Spectrum.* **E. Wagner.** (Phys. Zeits. 21. pp. 621–626, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—In a previous paper [Abs. 440 (1919)] it was shown how precision measurements of the quantum constant h could be made from observations of the maximum frequency in the continuous Röntgen spectrum and the energy of the kathode rays. A discussion of the results leads to the conclusion that h has a value $(653 \pm 1) \times 10^{-29}$ erg. sec., in exact agreement with the results of Webster [Abs. 1046 (1916)], and Webster and Clark [Abs. 507 (1917)]. This result is based on Millikan's value $4{\cdot}774 \times 10^{-10}$ e.s. unit for e.

As regards the dependence of the continuous Röntgen spectrum on the inclination of the Röntgen beam to the kathode beam, it was found that there was no perceptible influence of the direction of emission on the minimum potential, and hence on the minimum wave-length at constant potential. Spectral intensity distribution curves are given for azimuths of 90° and 150° for a potential of 10,200 volts. Measurements for other azimuths, particularly 0° and 180°, will be given later. The paper concludes with a discussion of various points in the theory of the continuous Röntgen spectrum. A. W.

457. *Absorption of X-rays by Chemical Elements of High Atomic Numbers; Critical Absorption Wave-lengths in K-series.* **W. Duane, H. Fricke,** and **W. Stenström.** (Nat. Acad. Sci., Proc. 6. pp. 607–612, Oct., 1920.)—A critical absorption wave-length characteristic of a chemical element is a wave-length such that the element absorbs X-rays of wave-length longer than the critical value, to a less extent than it does X-rays shorter than that value. Each chemical element has one critical

absorption wave-length associated with its K-series of characteristic emission lines. In the research now described the authors have measured the critical absorption wave-lengths in the K-series of most of the available chemical elements from tungsten to uranium, both inclusive. They used an ionisation spectrometer and examined spectra of the first, second, and third orders. The results obtained are included in the following table :—

K Critical Absorption Wave-lengths, $\lambda \times 10^8$ cm.
for Calcite $\lambda = 6{\cdot}056 \times \sin\theta \times 10^{-8}$ cm.

Chemical Element.	Atomic Number.	de Broglie.	Siegbahn-Jönsson.	Authors' Values.					
				First.	Second.	Third.	Average.	$\sqrt{(1/\lambda)}10^4$	Difference.
Tungsten..	74	—	—	0·1783	0·1781	0·1780	0·1781	2·370	
Platinum..	78	0·152	0·1578	0·1582	—	0·1581	0·1581	2·515	0·036
Gold	79	0·149	0·1524	0·1537	—	0·1532	0·1534	2·553	0·038
Mercury ..	80	0·146	0·1479	0·1493	—	0·1488	0·1491	2·590	0·037
Thallium..	81	0·142	0·1427	0·1448	—	0·1449	0·1448	2·628	0·038
Lead	82	0·138	0·1385	0·1412	0·1409	—	0·1410	2·663	0·035
Bismuth ..	83	0·133	0·1346	0·1375	0·1369	—	0·1372	2·700	0·037
Thorium ..	90	—	0·1127	0·1139	0·1124	—	0·1131	2·974	0·039
Uranium ..	92	—	0·1048	0·1075	—	—	0·1075	3·051	0·037

Results.—The results indicate that, within the limits of experimental error, the values of $\sqrt{(1/\lambda)}$ increase uniformly with the atomic number. It is also of importance to note that the authors' values, obtained by an ionisation method, are uniformly larger than those obtained by Siegbahn and Jönsson using a photographic method. The reasons for this difference are discussed. A. B. W.

458. *Soft X-rays ; a Note of Interpretation.* **H. M. Dadourian.** (Phys. Rev. 16. pp. 481–485, Nov., 1920.)—*Discussion of Earlier Paper.*—Some of the results described in an earlier paper are discussed and are shown to be capable of interpretations different from those given by Miss Laird [Abs. 110 (1920)].

Additional Facts.—Certain experimental details and results which did not appear in the original paper are given here as further evidence for the soundness of the conclusions therein derived. Author.

459. *Characteristic Absorption of X-rays : L-series.* **W. Duane** and **R. A. Patterson.** (Nat. Acad. Sci., Proc. 6. pp. 509–518, Sept., 1920.)—Critical absorption wave-lengths associated with the L-series of X-rays have been measured by E. Wagner [Abs. 1269 (1915)] and M. de Broglie [Abs. 270 (1918) and 386 (1920)]. These workers have investigated the spectra of ten of the chemical elements from tungsten to uranium, both inclusive. Each employed a photographic X-ray spectrometer with a rock-salt crystal. De Broglie found two critical absorption wave-lengths characteristic of each element, except in the case of mercury, for which he gives only one. For bismuth, thorium, and uranium he found a third weak band.

Method and Results.—In the investigation now described the authors employed an ionisation spectrometer with a calcite crystal. For each of the nine elements examined they find three critical absorption wave-lengths. The paper concludes with a brief discussion of the bearing of

the new data on certain empirical laws and on recent theories (notably Sommerfeld's) of the mechanism of X-radiation. A. B. W.

460. *Production of X-rays by Kathode Rays in Air at Atmospheric Pressure.* **W. Wolff.** (Phys. Zeits. 21. pp. 507–510, Oct., 1920. Extract of Dissertation, Giessen.)—When kathode rays emerge into the air after passing through the window of a Lenard tube X-rays are produced. F. Mayer (Dissertation, Heidelberg, 1917) has discussed the influence of this effect on measurements of the absorption of kathode rays in gases. The author now describes an experimental examination of the X-radiation produced in air by impact of kathode rays. An ionisation method of examination was employed, since a 15-hour exposure of a photographic film to the spectrum of the radiation produced no visible result. The presence of a characteristic K-radiation was demonstrated conveniently by means of an electrometer. A. B. W.

461. *Intensities of X-rays of the L-series.* III. *Critical Potentials of the Platinum and Tungsten Lines.* **F. C. Hoyt.** (Nat. Acad. Sci., Proc. 6. pp. 639–644, Nov., 1920.)—The work here described is a continuation of that of Webster and Clark [Abs. 507 (1917)] and Webster [Abs. 724 (1920)]. The methods used by them are applied to the classification of some lines that were doubtful, and the general validity of the intensity laws is tested by the use of a different metal as antikathode (tungsten). The classification of the lines, to date, is given below. Those for which further work is necessary are marked with a query :—

L_1 l_1, α_2, α_1, β_2, β_5, β_7.
L_2 η, β_1, γ_1.
L_3 β_3, β_4, γ_2 (?), γ_3 (?), γ_5 (?), γ_4.

A. B. W.

462. *Absorption of X-rays by Matter.* **L. de Broglie.** (Comptes Rendus, 171. pp. 1137–1139, Dec. 6, 1920.)—The author calculates the critical K-absorption discontinuities, and shows that these are in good agreement with theory. A. B. W.

RADIO-ACTIVITY.

463. *Brightness Decrease of Radio-active Paints.* **G. Berndt.** (Zeits. techn. Physik, 1. 5. pp. 102–107, 1920.)—The author, acquainted only with the measurements of Marsden and Rutherford, made experiments, interrupted after nine months. The first 7 samples (*a*) contained from 0·2 to 0·02 mgm. of Ra per gm. of a certain zinc sulphide, three other samples (*b*) contained 0·1 mgm. Ra, 0·5 mgm. mesothorium + 0·5 mgm. radiothorium, and 0·066 mgm. radiothorium respectively per gm. of another zinc sulphide. Rutherford's formula is confirmed ; the constant A is, however, found not to be proportional to the radium percentage, but to increase at a slower than linear rate. Assuming the relation to hold generally, the brightness would, in a period of five years, in the (*a*) samples, decrease very little in the weakest Ra preparations, but sink to 20 % and less in the preparations containing 0·025 mgm. Ra and more. In the (*b*) preparations decrease to less than 20 % was more rapid. It was noticed that a luminous paint prepared with dry ZnS darkened much more slowly than when prepared with aqueous solution of the salts. H. B.

464. *Electrical "Balance" Ionisation Method for Measurement of Recoil Radiations.* **A. L. McAulay.** (Phil. Mag. 40. pp. 763–770, Dec., 1920.)—In the course of a research made with the object of investigating soft X-radiation produced by the impact of α-rays on metal targets, it was found that there was an easily detectable increase in ionisation in a chamber beyond the range of the α-particles when they were fired through hydrogen instead of through air Various tests made to determine the nature of this effect showed that it was due to a stream of hydrogen atoms set in swift motion by collisions with α-particles. Rutherford has investigated this radiation by the scintillation method [Abs. 912 (1919)]. An investigation is now described in which the recoil-radiations are examined by a "balance" ionisation method. This electrical method has many advantages over one based on counting scintillations; thus, probability variations are negligible, and a smaller number of determinations are necessary to fix a magnitude with certainty. The results of observation confirm Rutherford's scintillation experiments, which show that in close collisions between α-particles and hydrogen atoms, the nuclei cannot be considered as point charges, and that most of them are thrown straight forward. It does not show any essential difference between curves which plot ionisation against absorption and those which plot scintillations against absorption, except for a slightly increased range observed in the ionisation method. A. B. W.

465. *Independent Origin of Actinium.* **E. Q. Adams.** (Am. Chem. Soc., J. 42. pp. 2205–2208, Nov., 1920.)—The author summarises this paper as follows:—(1) The assumption (made by Picard) that the actinium series is derived neither from Ur I, nor from Ur II, but from a third isotope (actino-uranium), does not require (as Soddy supposed) the identity of period of the first and third. (2) The relation of the three series (Ur, Ac, and Th) becomes more symmetrical if a hypothetical isotope of protactinium (=eka-tantalum = UrZ) be assumed as the parent of actino-uranium by a β-ray transformation. (3) This element, and likewise actino-uranium, is predicted to have an atomic weight 235, corresponding to prot-Ac 231, Ac 227, and Ac-lead 207. (4) This last value agrees well with Hönigschmidt's value of 206·05 for the atomic weight of Ur-lead containing approximately 3 % of Ac-lead.
A. B. W.

466. *Variation with Pressure of the Residual Ionisation due to the Penetrating Radiation.* **K. M. Downey.** (Phys. Rev. 16. pp. 420–437, Nov., 1920.)—*Residual Ionisation in Closed Vessels : Experimental Method.*—In order to throw light upon the type of radiation responsible for the residual ionisation in closed vessels, the author has measured the ionisation in a *sphere* 1 *ft. diam.* for pressures *ranging up to* 21·5 *atmos.* Any corpuscular radiation not absorbed in the ionisation sphere has a penetration at 1 atmosphere equal to or greater than the *product of the dimension of the sphere* and the *number of atmospheres pressure.* A special device was used to compensate for any fluctuations of the battery furnishing the high potential required for saturation. This consisted of two ionisation spheres of the same electrical capacity, which were connected to the opposite ends of a 10-megohm resistance, the mid-point of which was earthed. Connections from the battery were made

to the ends of the ten megohms. The final experiments were performed *over water* to eliminate any effect due to *radio-active substances in the soil.*

Nature of Ionisation Curve.—The *shape of the ionisation–pressure* curves gives information as to the process of ionisation. A *discussion* of such curves obtained by other observers has been given in connection with those of the author. The curves obtained in the *present experiment* give a *linear relation.* This indicates that the ionisation is not due to a soft radiation from the walls of the sphere, but that it is due *either to the direct action of a penetrating radiation* without any effect produced by secondary β-rays from the gas, or to a *secondary, corpuscular radiation from the walls of the vessel.* If the latter is responsible for the main portion of the ionisation, the experiments indicate that it has a *penetration of at least* $6\frac{1}{2}$ *m. in air at atmospheric pressure.*

Diurnal Variation.—A few curves obtained during the preliminary observations have been given. Provided that the sky is not cloudy, these indicate the existence of a diurnal variation.

Ionisation in Air due to Gamma Rays of Radium.—The ionisation in a sphere 1 ft. diam. has been measured for pressures ranging up to 40 atmos. From four to twenty atmospheres a linear relation existed. The change in slope at twenty atmospheres to a value about 6/10 of that at lower pressures may be attributed to some of the β-rays having completed their paths. At the high pressures there is a suggestion of an effect due to the secondary radiation from the air. AUTHOR.

467. *Scattering of X- and γ-Rays.* **J. A. Gray.** (Frank. Inst., J. 190. pp. 633–655, Nov., 1920.)—The author shows that when an ordinary beam of X- or γ-rays (*i.e.*, one not obtained by reflection from crystals) is scattered, the rays scattered in any definite direction are of quite a different type from that of the primary rays. This type depends on that of the primary rays, the angle of scattering, and, possibly, on the nature of the scattering material. The effect is such that the scattered rays become less and less penetrating than the primary rays, the greater the angle of scattering. The distribution of the scattered radiation for all types of X and γ radiation is similar, less radiation being scattered through 90° than in any other direction. A discussion is given on the effect of scattering upon absorption problems. Theoretically it appears possible to explain the results of experiment on the hypothesis that X-rays consist of a series of pulses, and evidence is given that this should be the case. When the primary rays are of definite wave-length, as when reflected from the crystal, the scattered rays should be of the same wave-length. A. B. W.

468. *Direct Method of Determination of the Range of α-Particles in Solid Bodies.* **H. v. Traubenberg.** (Zeits. f. Physik, 2. 3. pp. 268–276, 1920. Phys. Zeits. 21. pp. 588–590, Nov. 1 and 15, 1920.)—In the method described the solid substance under consideration is shaped to form a thin wedge. On the upper surface of this wedge is placed a zinc sulphide screen—with the crystals in contact with the wedge. The wedge is mounted over a narrow slit in a base board, the slit being arranged along a line of increasing thickness of the wedge. A wire coated uniformly with active material (*e.g.*, with RaC, after exposure to emanation) is placed along the slit and the α-rays emitted are incident

on the lower surface of the wedge, which they are able to penetrate up to a certain critical thickness. Thus a line of luminescence is produced on the zinc sulphide screen, the length of this line increasing with increased penetrating power of the α-rays. The thickness of the wedge was measured accurately by means of a Zeiss thickness gauge; an accuracy of $1\mu = 10^{-4}$ cm. being attained. The experimental values of the range of RaC α-particles in various elements are tabulated and compared with the theoretical values deduced from various formulæ. The experimental values are as follows:—Li 129μ, Mg $57{\cdot}8\mu$, Al $40{\cdot}6\mu$, Ca $78{\cdot}8\mu$, Fe $18{\cdot}7\mu$, Ni $18{\cdot}4\mu$, Cu $18{\cdot}3\mu$, Zn $22{\cdot}8\mu$, Ag $19{\cdot}2\mu$, Cd $24{\cdot}2\mu$, Sn $29{\cdot}4\mu$, Pt $12{\cdot}8\mu$, Au 14μ, Tl $23{\cdot}3\mu$, Pb $24{\cdot}1\mu$. A. B. W.

469. *Number and Range of Recoil Atoms from ThC and ThC′.* **W. Kolhörster.** (Zeits. f. Physik. 2. 3. pp. 257–263, 1920. From the Physikal.-Techn. Reichsanstalt.)—When a radio-active substance emits an α-particle the newly created product from the mother substance recoils with momentum equal to that of the α-particle emitted. Thus it has been found (by Wertenstein, Wood and others) that the range of the recoil atoms is of the order of 0·1 mm. to 0·3 mm. in air at atmospheric pressure.

The author now applies the method of counting α- and β-particles developed by Rutherford and Geiger to count the recoil atoms also. As a result of the investigation the author shows that the recoil atoms from ThC are divided into two principal groups, just as are the α-particles; also it is shown that the total number of recoil atoms is exactly equal to the number of α-particles. The ranges of the recoil atoms in air and hydrogen have been found to be in close agreement with those previously determined by A. B. Wood [Abs. 258 (1914)], using different methods of measurement. A. B. W.

470. *Heat Emission in the Transformation of RaB.* **H. Herszfinkiel** and **L. Wertenstein.** (J. de. Physique et le Radium, 1. pp. 143–145, Nov., 1920.)—The liberation of heat from radio-active substances emitting β-rays is interesting to study: for heat being the ultimate effect of all the manifestations of radio-activity, there exists a means of deciding if there exist, apart from the α-, β-, and γ-radiations, other forms of emission of radio-active energy. Substances emitting β-rays are more suitable for such a study than those emitting α-rays; for the production of heat in the latter case would probably be so great as to mask the feeble effects of the energy emission under examination. Reference is made to the work of Rutherford on the heat produced in the decay of radium-active deposit. He showed that the heat emitted from RaB was negligible compared to that from the other products. Rutherford's method, however, was not sensitive, as he himself pointed out, for the results would not have been modified if the heat from RaB were equal to 10 % of the heat from RaC.

The authors have re-opened the question, using as source of heat RaB as free as possible from the radio-active products. The curve of decay in this case has a maximum. This curve will be identical with the curve of growth of RaC in the case where the production of heat from RaB is nil. In the opposite case, this curve—plotted logarithmically—will be still superposable on the RaC curve, but will "lag" behind the latter curve by a time "t." It is easy to deduce from the value of this lag "t" the

ratio of the amounts of heat liberated from equivalent quantities of RaB and RaC. On comparing the "log" curve of heat emission with the "log" curve of growth of RaC (measured by γ-rays), the authors find that the two curves are superposable, but the heat curve is displaced from the RaC curve by a *negative* time equal to 2 minutes (3 experiments gave 1·5, 2, 2·5 mins.). In other words, the liberation of heat is retarded, relative to the growth of RaC, by 2 minutes. This lag is, however, only apparent, for in an independent experiment the authors show that there is a delay of 2 minutes between the liberation of heat and its reception. Thus it is shown that, subject to experimental errors, the curve of production of heat by RaB + C is superposable on the curve of growth of RaC.

Results.—The results indicate that the heat produced by RaB is *at most* 2 % of the heat liberated from RaC. It is therefore possible to affirm that the heat produced in a β-ray transformation is due solely to the energy emitted by the β-rays. A. B. W.

471. *Visibility of the Tracks of α-Particles in Phosphorescent Zinc Sulphide.* **H. Herszfinkiel** and **L. Wertenstein.** (J. de. Physique et le Radium, 1. p. 146, Nov., 1920.)—The range of α-particles in zinc sulphide is of the order of some hundredths of a millimetre. Consequently the scintillation due to an α-particle falling at grazing incidence on a screen of zinc sulphide in a sufficiently thick layer should produce, if sufficiently high magnification is employed, the effect of luminous thread. To demonstrate this phenomenon the authors have used a microscope with immersion objective and a source of radium-active deposit. A. B. W.

472. *Protactinium: Period and Occurrence in Uranium Minerals.* **O. Hahn.** (Phys. Zeits. 21. pp. 591–592, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—In a previous communication the author and L. Meitner gave as the half value period of the life of protactinium a value lying between 1200 and 180,000 years. This value was deduced from measurements of the range of α-particles emitted by this substance. Since an exact knowledge of its period is of some importance further measurements have been made to obtain a more definite value than that stated above. The following values are now given:—

From 141 gm. Uran. nitrate (at least 20 years old) the period = 12,800 years.

From 86 gm. Uran. nitrate (at least 52 years old) the period = 11,800 years.

From 33 gm. Sodium Uranate + 21 gm. Uran. Acetate (at least 60 years old) the period = 12,300 years.

These values are in good agreement, and it therefore appears that the half-value period of protactinium is about 12,000 years. Using this value and taking the period of uranium to be 5×10^9 years, the author deduces the relative amounts of Ur and protactinium in minerals. Thus it is shown that for every 10^6 gm. of Ur in the mineral, there are 72 mgm. of prot-Ac and 330 mgm. of radium. A. B. W.

473. *Nature of Ions produced in Air by Radio-active Bodies; Ions of High Mobility.* **J. J. Nolan.** (Roy. Irish Acad., Proc. 35. pp. 38–45, Dec., 1920.)—

In an examination of the ionisation produced by spraying water, the author obtained evidence of the existence of a great variety of ions, some of them of much greater mobility than that ordinarily attributed to the small ion in air. A more complete examination revealed that several groups of such mobile ions existed, some of very high mobility. In addition, a number of other groups were separated out, the mobilities of which roughly corresponded with those observed for ions produced in air by the ordinary ionising radiations. Four such groups were especially noted. These groups contained ions having for mobility in unit field (volt/cm.) the values 1·94, 1·70, 1·49, and 1·34 cm./sec. respectively. It was suggested by the author (1) that all these ions consist of clusters of water-molecules of different sizes, the very mobile ions corresponding to the very small groups (one, two, three molecules, etc.), and the others, such as the four mentioned above, consisting of larger groups of regularly graduated size; (2) that the ordinary small ion in air and other gases is also a stable cluster of water-molecules, identical with one or other of the four forms mentioned above, the particular form prevailing at any time depending on the sign of the charges, and also on the degree of humidity.

Using radio-active sources of ionisation, the author has since repeated his observations of mobilities by the same method as that devised for the measurement of mobility of spray-ions. The results of these observations show conclusively (1) that when ionisation is produced in moist air by radio-active substances the bulk of the ionisation is carried by ions of four distinct classes, having mobilities 2·0, 1·78, 1·56, and 1·40 approximately; (2) that among negative ions the two faster groups tend to predominate, while among positive ions the slowest kind carries a large part of the ionisation; (3) that, in addition, ions of mobility up to 12·5 are present in distinct groups, but in small quantities. A. B. W.

474. *Variations of the Radio-activity of the Waters of Bagnoles-de l'Orne and their Relation to Rainfall.* **P. Loisel.** (Comptes Rendus, 171. pp. 858–860, Nov. 2, 1920.)—An investigation of the radium emanation content of springs as affected by rainfall. A definite relation was observed, there being a certain lag between diminution of radio-activity and fall of rain. A. B. W.

475. *Radio-active Analysis of the Thermal Waters of Bagnères-de-Luchon.* **A. Lepape.** (Comptes Rendus, 171. pp. 731–733, Oct. 18, 1920.) —The analysis described indicates that the waters from this source are very rich in radium emanation; they contain on an average about 30 millicuries per litre. Compared with other sources, this places the waters of Bagnères-de-Luchon in the premier position in France. A. B. W.

HEAT.

476. *Melting-Point of Glass; New Definition.* **F. Weidert** and **G. Berndt.** (Zeits. techn. Physik, 1. 6. pp. 121–123, 1920.)—Describes a method of defining the melting-point of glass. A cube of the glass is half embedded in kieselguhr with one diagonal vertical, so that the upper half of the cube appears as a square pyramid above the level of the kieselghr. The cube is then heated to a known temperature for a given time and slowly cooled. The temperature at which the glass has flowed so as to leave just a trace of the apex of the pyramid detectable by touch is only 20 deg. below the temperature required for complete flattening to perfect smoothness in the same time. The mean of these two temperatures is defined as the melting-point and a table is given for the melting-points of different glasses as found with different periods of heating (from ½ hour to 6 hours). In the case of a certain flint, the melting-points for these two extreme periods differed by only 30 deg. C. J. W. T. W.

477. *Thermal Conductivity of Water; New Form of Apparatus Employed.* **M. Jakob.** (Ann. d. Physik, 63. 6. pp. 537–570, Nov. 16, 1920. From the Physikal.-Techn. Reichsanstalt.)—After an account of previous work on this subject a description is given of a new form of apparatus for the determination of the thermal conductivity of water from 0° to 80° C. A very thin layer of water between heavy copper plates was employed, and the precautions taken to reduce the amount of the correction necessary are described in detail. The amount of this correction did not exceed 10 % at the highest temperature employed. It was found that the results could be represented by the equation $\lambda = 0{\cdot}001325\ (1 + 0{\cdot}002984\ t)$ in calories per cm. per sec. per degree. It is considered that the values given by this formula are correct to 1 %. The method is being used for other liquids. J. W. T. W.

478. *Convection of Heat and Similitude; Heat-Loss Results from Model Experiments.* **A. H. Davis.** (Phil. Mag. 40. pp. 692–703, Dec., 1920.)—The heat-losses from a hot body may be due to conduction, radiation, and convection. While the two former may be calculated, if the constants of the materials and surfaces be known, the loss by convection is complicated by its dependence on the geometrical form of the surface. Although for the simplest forms (spheres, cylinders, etc.) the effect may be calculable, in general it can only be found by experiment, using either the actual object or one of similar form. Mathematically, convection is a combination of hydrodynamics with the Fourier equations for heat-flow, and in the solution of the purely hydrodynamic problems presented by ships and aircraft, the value of experiments with models has been proved. Accordingly relations are derived applicable to convection from the standpoint of models. Section 1 deals with natural convection, the following formulæ being utilised :—

Natural convection ..... $h = (k\theta/l)\ \mathrm{F}\ (c^2gl^3a\theta/k^2)$
Forced convection ..... $h = (k\theta/l)\ \mathrm{F}\ (lvc/k)$.

Section 2 deals with convection from a body in a stream of fluid. Graphs drawn with $h/(k\theta/l)$ as ordinate and either $(c^2gl^3a\theta/k^2)$ or (lvc/k)

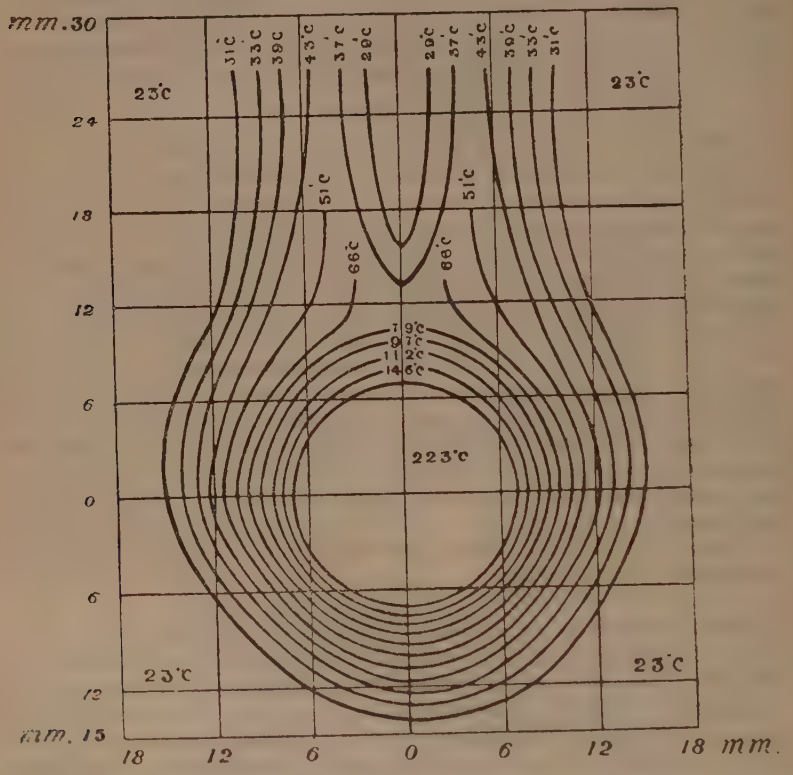
as abscissa should be independent of the size of the object; consequently to ascertain the heat-loss for any particular body it should be necessary only to perform the appropriate experiment with a model. For natural convection Péclet's data have been analysed with promising result. The formula would not be applicable to bodies where the fluid expansion caused was no longer negligible as a mere volume change. For forced convection the formula, tested by data given by Hughes, is very promising. The cooling fluid is not heated so much as in natural convection, and can still be regarded as incompressible for smaller bodies at higher temperatures. The formula is good, even for thin wires, and it is satisfactory to trace in it the hydrodynamic variable determining turbulence. Evidence available in published data indicates that, for heat-loss from a body, an excellent first approximation can be obtained from experiments with a model. The principle of similitude affords a convenient method of expressing experimental results. H. H. Ho.

479. *The Disappearing Filament Type of Optical Pyrometer.* **W. E. Forsythe.** (Faraday Soc., Trans. 15. pp. 21–50; Disc., 50–53, June, 1920.)—The paper was contributed to a Symposium on Pyrometry arranged by the Faraday Society. It is a useful summary of the work of the author and others on this type of instrument. The main points dealt with are as follows:—Filaments suitable for pyrometer lamps; monochromatic screens and methods of calculating their "effective" wavelengths; calibration of pyrometer against the melting-points of Au and Pd; use of rotating sectors and absorbing glasses for cutting down intensity of source; discussion of various sources of error and examples of the accuracy attainable; use of tungsten strip lamps as standards of temperature. There is, further, an account of the intercomparison of temperature scales carried out by a number of laboratories in America by means of standard tungsten lamps circulated by the Nela Research Laboratory.

Both the laboratory and commercial types of disappearing-filament pyrometer are described. E. G.

480. *Convection from Heated Cylinders in Air.* **B. Ray.** (Indian Assoc. for Cultivation of Science, Proc. 6. 1 and 2. pp. 95–107, 1920.)—Describes the results of an experimental investigation of the free and forced convection of heat from horizontal cylinders in air. The general character of the temperature distribution round the cylinder was optically observed by the method of the Foucault test and quantitatively, determined by thermoelectric measurement of the temperature of the air. It was found that in *free* convection there is a relatively large region of heated air surrounding the cylinder, the temperature gradients are relatively small, and the region above the middle of the cylinder is actually cooler than the region vertically above its two edges. Immediately on the surface of the cylinder itself, the gas appears to be quiescent, the movement increasing with distance from the cylinder on either side. There is probably no actual discontinuity of temperature at the boundary itself, but there is a rapid fall of temperature at a short distance from the surface. In *forced* convection the layer of heated air is much thinner and the temperature gradients correspondingly greater. There is a noticeable difference in the thickness of the fringe of heated air on the leeward and windward sides of the cylinder, and this thickness decreases with increasing velocity

of the air current. The " horns " or currents of heated air moving away from the cylinder are much sharper in forced convection than in free convection. It appears that there is little or no slipping between the fluid and the solid at the boundary, and no actual discontinuity of temperature, though there is a rapid fall of temperature close to the boundary. Though there is no actually stationary film of finite thickness of gas in contact with the solid, there appears to be very little motion in the immediate neighbourhood of the boundary, and presumably at the boundary itself the gas is at rest. By considering the effect of viscosity of the fluid, it would seem possible to explain the effects observed, though previous



mathematical theories of convection would appear to require modification to take account of the effect of viscosity and to enable the observed form of the isothermals to be explained. The isothermals found in a particular case of free convection are shown in the Fig. J. W. T. W.

481. *Isotherms of Hydrogen.* **L. Holborn.** (Ann. d. Physik, 63. 7. pp. 674–680, Dec. 1, 1920. From the Physikal.-Techn. Reichsanstalt.)—This paper is an extension to hydrogen of a previous investigation of the isotherms of air, argon, and helium [see Abs. 92 (1916)]. The temperatures employed were 0°, 50°, and 100°, while the pressures ranged between 20 and 100 atmos. The former experimental arrangements were employed without essential changes, and these are very briefly described. The hydrogen was obtained by the electrolysis of dilute sulphuric acid, passed

twice over solid caustic potash, then over red-hot copper and finally dried by means of phosphorus pentoxide. The method of conducting the gas into the measuring apparatus is described at length and the experimental results are given in three tables. The isotherms for 50° and 100° are linear, but at 0° a deviation from the straight line appears. Equations for the isotherms are then derived, and the similar results of Kamerlingh Onnes discussed. Two further tables give the pv values obtained from the formulæ, and the expansion and pressure coefficients between 0° and 50° and 0° and 100° respectively. It was found that the inclination of the hydrogen isotherms with respect to the p-axis increased with increasing temperature, while the contrary was the case for helium. H. H. Ho.

482. *Specific Heats at Low Temperatures* (*Na, Sb, LiH*). **P. Günther.** Ann. d. Physik, 63. 5. pp. 476–480, Nov. 3, 1920.)—Gives the results of further determinations of specific heats at very low temperatures. Values are now given for Na, Sb, and LiH. J. W. T. W.

483. *Theory of Thermal Radiation.* **Z. Klemensiewicz.** (Comptes Rendus, 171. pp. 1210–1212, Dec. 13, 1920.)—Derives Planck's equation from the supposition that radiation is due to the impacts of molecules with electrons, or even those between two electrons. The theory is worked out for the case of a gas, but is applicable to all bodies. J. W. T. W.

484. *Accurate Method for the Determination of Vapour Pressure; Differential Tensimeter.* **E. J. Hartung.** (Faraday Soc., Trans. 15. pp. 150–159, June, 1920.)—A description is given of an improved form of differential tensimeter, which allows of the determination of vapour pressures with a high degree of accuracy. None of the liquids previously proposed as manometer liquids gives satisfactory results, and the author recommends for this purpose the hydrocarbon, dibenzyltoluene; the latter is unobtainable commercially and a method for its preparation is described. Special attention must be paid to the exhaustion of the instrument prior to taking a measurement. Measurements were made with solutions of potassium chloride and sulphate, and of sulphuric acid. T. H. P.

485. *Calculation of the Latent Heat of Vaporisation from Critical Data.* **W. Herz.** (Zeits. Elektrochem. 25. pp. 323–324, Oct. 1, 1919.)—Combining the formulæ of Guye and of Prudhomme for the molecular heat with Trouton's law for the latent heat, the author arrives at the formulæ $L = p_k \cdot T_s/T_k \cdot d_k$ and $L = 2p_k/d_k$, where the k refers to the critical pressures; temperature T, and density d, and s to the boiling-point. The latent heats so calculated agree fairly well with the observations in the case of about 20 organic substances (hydrocarbons, their esters, benzene, etc.) and for oxygen, nitrogen, sulphur dioxide. They do not agree at all in the case of water and methylalcohol, supposed to be associated, but are in approximate agreement again for acetic acid, also believed to be associated. H. B.

486. *Rapid Determination of Critical Temperature; Carbonyl Chloride.* **L. Hackspill** and **Mathieu.** (Soc. Chim., Bull. 25. pp. 482–485, July, 1919.)—A solid cylinder of copper or Al, 25 cm. long, 5 cm. diam., is pro-

vided with an axial boring to take the liquid to be studied in a stout glass tube; the cylinder is slit longitudinally for inspection of the meniscus in the tube. A thermometer is placed in another hole. The cylinder is wound with resistance wire and the whole is placed in a bath. Carbonyl chloride $COCl_2$ (phosgene) gave the critical temperature $183 \pm 0{\cdot}5°$; according to Marcel Oswald it should be 190°. H. B.

487. *Determination of Gas Volumes at Low Temperatures.* **R. Mewes.** (Zeits. f. Sauerstoff u. Stickstoff Ind. 10. pp. 81–82, Nov. 1918.)—Theoretical considerations and the experimental data for helium, hydrogen, nitrogen, oxygen, and air (free from CO_2 and CO) show that at low temperatures (down to about — 192°), Gay Lussac's law does not hold even approximately, and that the most accurate observations of specific volumes must be vitiated by some undetected error.

Specific Heat of Gases at Low Temperatures. (*Ibid.*, 10. p. 91, Dec., 1918.)—The specific heat steadily decreases, as previously shown, with sinking temperature in accordance with the formula $C_{pt} = C_{p-182}(1 + d)^t$, taking — 182° as zero. This formula agrees with Scheel's values.

Investigation of the Law of Mewes; Change of Gas Volume with Temperature. (*Ibid.*, 11. pp. 13–15, Feb., and pp. 29–30, April, 1919.)—The author had modified the formula of Gay Lussac, replacing it by $v_t - x = (v_0 - x)(1 + \alpha)^t$ or approximately $v_t = v_0(1 + \alpha)^t$, where $\log (1 + \alpha) = 0{\cdot}00111$. For temperatures above 0° the two formulæ agreed, but at lower temperatures his values differed more and more from those of Gay Lussac. The ratio of the density at 0° to the density at the boiling-point of oxygen, — 182°, is about 3 according to Gay Lussac, and about 2 according to R. Mewes. Most other investigators not having confirmed Mewes' formula, he re-determines, together with L. Neumann, the data of H, N, O, air at decreasing temperatures and finds errors in all the methods used, including his own. The ratio of the liquefied portion to the total amount can mathematically be deduced; but when the corrections for partial liquefaction and surface condensation are made, they are found little to affect the final values, especially in the case of hydrogen, and the discrepancies remain so far unexplained.

Investigation of Poisson's Law by Means of Gas Volume and Specific Heat at Low Temperatures (*ibid.*, 10. p. 93, Dec., 1918.)—Years ago the author gave a formula for calculating the specific volume from observations of the specific heat $k = c_p/c_v$ and of c_p at low temperatures. Calculating v_{15}/v_t and v_0/v_t from $v_{15}/v_t = (1 + \alpha)^{-t}$ and from

$$v_{15}/v_t = [A \,.\, t(c_p - c_p/k)/P + v_{15}]$$

and introducing the values into Poisson's ratio, the author finds very marked discrepancies between calculated and observed values; Poisson's ratio is hence questioned. [There are similar papers, concerning especially also Linde's figures, in vols. 10 and 11 of the journal.] H. B.

SOUND.

488. *Velocity of Sound from a Moving Source.* **R. B. Abbott** and **J. W. Cook.** (Phys. Rev. 16. pp. 486-492, Nov., 1920.)—*Poynting's Theoretical Velocity Equation* and a discussion of it are quoted from his original article. The equation is $X = (E - r_0U^2)(dy/dx)$, where X = external pressure, U = resultant relative velocity of propagation, E = elasticity, dy/dx = volume change, and r_0 = density. The *corroborations* obtained by Alter are stated to be: first, hearing the whistle of high-velocity shells before they strike a target near the observer; second, calculations, based upon Poynting's equation, of the velocities measured by Mach, Berthelot, and Wolf at various distances from the points of explosions. The calculated values agree with the observed values.

Observations taken in the *laboratory* did not show any change in the velocity of sound due to a spark source moving at 8550 cm. per sec. The source consisted of a spark-gap mounted on the end of a vane rotating at 30 revs. per sec. The spark was made to occur at the same point once in a revolution. Opposite points on the spherical wave-front were located by two telephone transmitters and one receiver connected to a differential transformer. A minimum sound in the receiver indicated that the wave-front arrived at the two transmitters simultaneously. The radii of the spherical waves measured varied from 190 to 260 cm. Normal room temperature and pressure prevailed. AUTHORS.

489. *Largest Amplitudes at Acoustic Frequencies.* **A. du Bois-Reymond.** (Zeits. techn. Physik, 1. 8. pp. 165-166, 1920.)—It is here shown that the greatest attainable amplitude of a given vibrating system for each frequency is a constant for the material of that system. As an example, a bar fixed at one end (in an infinite mass) and free at the other is considered. For the frequency of 50 periods per sec. the greatest attainable amplitudes for four common substances are given as follows: Steel, 2·4–9·7 mm.; bronze, 2·6–3·3 mm.; brass, 2–2·6 mm.; wood, 4–8·1 mm. E. H. B.

490. *Experiments with Mechanically-played Violins.* **C. V. Raman.** (Indian Assoc. for Cultivation of Science, Proc. 6. 1 and 2. pp. 19-36, 1920.)—This paper describes the construction of a mechanical violin-player intended for the study of the acoustics of the instrument. The chief results so far obtained may be summarised as follows:—

(1) Effect of the *bowed region* on the bowing *pressure*: it is shown that the bowing pressure varies *inversely* as the *square* of the distance of the bow from the bridge.

(2) Relation between bowing *speed* and bowing *pressure*: it is shown that for very small speeds the bowing pressure tends to a finite minimum value.

(3) Variation of bowing *pressure* with *pitch*: the graph for the bowing pressure for different frequencies shows a series of *maxima* which approximately coincide in position with the resonance frequencies of the instrument.

(4) Effect of *muting* on bowing *pressure*: it is found that the mute

produces profound changes in the form of the graph. The bowing pressure is increased in the lower parts of the scale and decreased in the higher parts of the scale. [See Abs. 321 (1919) and 896 (1920).] E. H. B.

491. *Mechanical Illustration of Theory of Large Vibrations and Combinational Tones.* **B. N. Banerji.** (Indian Assoc. for Cultivation of Science, Proc. 6. 1 and 2. pp. 37–50, 1920.)—This paper gives an account of experiments illustrating the production of harmonics and combinational tones in systems having finite amplitudes. The apparatus consists of a swinging arm pivoted on a vertical axle and free to oscillate in a horizontal plane; the forces controlling this oscillation may be made symmetric or asymmetric as desired. From the swinging arm a number of pendulums are suspended which can be set in vibration. The behaviour of the pendulum can be observed and the displacement time graph of the swinging arm may be recorded by a pen on a rotating drum. The apparatus has been used to demonstrate the following phenomena among others :—

(1) The third partial in large amplitude vibration.

(2) The second partial in the forced vibration of an asymmetric vibrator.

(3) The influence of a resonator in magnifying components of motion.

(4) The production of beats under double forcing of symmetric and asymmetric systems.

(5) The production of combinational vibrations of an asymmetric vibrator under double forcing. E. H. B.

492. *Forced Vibrations of Strings under Damping Proportional to the Square of the Speed.* **R. N. Ghosh.** (Indian Assoc. for Cultivation of Science, Proc. 6. 1 and 2. pp. 67–86, 1920.)—This paper is both mathematical and experimental, the chief results obtained being briefly as follows. (1) For large amplitudes of vibration it has been found that the frictional resistance to the vibration of a string in air is approximately proportional to the square of the velocity. (2) The forced vibration of a simple vibrator resisted by forces proportional to the square of the velocity has been dealt with, and it is found that (*a*) the max. resonance is proportional to the square root of the impressed force, and (*b*) the sharpness of resonance is directly proportional to the frequency natural to the system, and inversely proportional to the *square root of the product of the frictional coefficient and the impressed force.* (3) In the vibrations of a string obtained by imposing a transverse obligatory motion at one point it is found that (*a*) the max. amplitude of vibration increases much less rapidly than in proportion to the obligation displacement, and (*b*) the effect of finite amplitude of vibration in shifting the resonance towards lower tensions is explicable. (4) The longitudinal type of Melde's experiment was also dealt with. E. H. B.

493. *Valve Transmitter as Normal Tone Scale.* **E. Grüneisen** and **E. Merkel.** (Zeits. f. Physik. 2. 3. pp. 277–296, 1920. From the Physikal.-Techn. Reichsanstalt.)—Describes a valve transmitter whose frequency from 700 to 46,000 per sec. can be read to an accuracy of one to two in ten thousand by the condenser adjustments. This arrangement is practically independent of the type of valve and the characteristic of the valve, provided that by a very small auxiliary condenser a *normal* state of the

transmitter is attained. The temperature coefficient of the frequency is about one ten-thousandth per degree. E. H. B.

494. *Triple Pendulums with Mutual Interaction and the Analogous Electrical Circuits.* I. **E. H. Barton** and **H. M. Browning.** (Phil. Mag. 40. pp. 611-618, Nov., 1920.)—*Experimental Method.*—The experiments here described were carried out with a modified form of the apparatus described in previous papers on coupled vibrations [Phil. Mag., Figs. 1 and 2, Oct., 1917, and Fig. 13, July, 1918: Abs. 1221 (1917) and 894 (1918)]. An extra bridle and pendulum were added and two or three connectors used instead of a single one as before. From the mathematical theory of three circuits coupled each to the other two, it was expected that the mechanical arrangement would give for each pendulum three superposed vibrations: the periods of these vibrations were expected to be the same for each pendulum. The phases and amplitudes might, however, differ for each pendulum, thus giving very different resultant vibrations. The results obtained with the first form of apparatus were even more complicated than was expected from three superposed vibrations, and on reflection this was seen to be due to the special arrangement in use. In the present paper are given only the experimental results with this first form of triple pendulum, the theory and experimental results of the simpler form being reserved for a later paper. The simple theory of triple electric circuits is here developed, ready for comparison with that of the mechanical case. This shows that each of the three electrical circuits may give vibration components of three frequencies, these frequencies being the same for each circuit, but differing in general from the frequencies natural to such circuit when isolated from its fellows. The looser the coupling the more nearly do the superposed vibrations approximate to those of the systems when free.

Results.—The experimental results obtained from the pendulum are exhibited in fifteen photographs, each showing triple traces of the vibrations occurring. When only *two* frequencies are present in the resultant vibration of any trace, there is, with loose coupling, a series of *equal* symmetrical cycles of waxing and waning amplitude as in the phenomenon of beats. When *three* frequencies are present these successive cycles are *unequal* in length, or a single cycle is specialised by waxing and waning at *different rates*. These latter effects are distinctly shown in a number of the cases included in this paper. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

495. *Geometrical Construction for Equipotential Surfaces.* **T. Thorkelsson.** (Phys. Zeits. 21. pp. 513-515, Oct. 1, 1920.)—Describes a geometrical construction for drawing equipotential surfaces due to electric or magnetic poles of different strengths. The method is illustrated by an example in which the construction is worked out. J. W. T. W.

496. *Electricity and Gravitation.* **H. Weyl.** (Phys. Zeits. 21. pp. 649–650; Disc., 650–651; Dec. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—This paper deals with an extension of the relativity theory to electromagnetic phenomena, which latter also appear to admit of the new geometrical treatment. Section I deals briefly with the essence of the Einstein theory of gravitation, II with analysis, III with physical magnitudes, IV with electromagnetic potential, V with the effect of electrical potential as a cosmic factor of essential significance for the problem of matter. In the *discussion*, Pauli, Einstein, Reichenbächer, and Mie took part. H. H. Ho.

497. *Electrical Field of a Charged Particle Rotating about a Gravitational Centre.* **G. Mie.** (Phys. Zeits. 21. pp. 651–659, Dec. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—In a lengthy introduction the author shows that, from the principle of relativity applied to the gravitational field, the remarkable hypothesis appears to follow that electrically charged particles afford no radiation from their rotatory motion. This result is the more amazing in that the Einstein theory does not depend on quanta conditions as does, for example, Bohr's atomic model. The chief object, therefore, of the present paper is to solve this problem, and for simplicity a circular orbit has been chosen for the particle which may be regarded either as a charged planet or an electron. It is shown that for a particle moving in empty space about a gravitational centre, application of the principle of relativity must not be made from the standpoint of an electric particle at rest in empty space, but from a particle in a rotatory electrical field. The paper is mathematical throughout. H. H. Ho.

498. *The Atomistics of Electricity and the Phenomena of Single Radioactive Test Particles of Dimensional Order* 10^{-5} *cm.* **F. Ehrenhaft.** (Phys. Zeits. 21. pp. 675-683; Disc., 683-688; Dec. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, 1920.)—*Electronic Charge by this Experimental Method.*—The average values obtained by previous workers with respect to the electronic charge and their variations has led the present author to a more exact experimental method. The latter briefly consists in comparing the weights of single spherical test particles charged with electricity and of dimensions of the order of 10^{-5} cm. with those produced in the homogeneous electric field. *Fractions of the ordinary accepted electronic charge* have thereby been established. The noble metals are especially suitable for the test bodies.

Discussion of Result.—The significance of this result with respect to the universality of the electronic charge is then discussed, as also to the fundamental part which the electron is conceived to play in the general structure of matter. Very complete experimental details are given. A very long discussion is included, in which the following took part :—E. Meyer, Konstantinowsky, Bär, Regener, Born, Gerlach, Fürth, and Weiss. H. H. Ho.

499. *Two Mutually Influencing Spheroidal Conductors.* **B. Datta.** (Tôhoku Math. J. 18. pp. 261–267, Dec., 1920.)—The distribution of electricity is considered on two prolate spheroids, the axes of revolution of which are coincident with the line joining their centres. The author takes two systems of ovary spheroidal coordinates (λ_1, u_1, ω) and (λ_2, u_2, ω), having their ordinates at the centres of the spheroids. The surfaces of the spheroids are given by $\lambda_1 = \lambda_{10}$ and $\lambda_2 = \lambda_{20}$. If ϕ denote the potential at any point we must have

(1) $\nabla^2\phi = 0$, throughout the space,
(2) $\phi = 0$, at infinity,
(3) $\phi = V_1$ when $\lambda_1 = \lambda_{10}$,
(4) $\phi = V_2$ when $\lambda_2 = \lambda_{20}$.

A value of ϕ which satisfies (1) and (2) is given by

$$\phi = \sum_0^\infty [A_n P_n(u_1) Q_n(\lambda_1) + B_n P_n(u_2) Q_n(\lambda_2)],$$

where A and B are arbitrary constants. He shows that it is possible to determine these constants so as to satisfy (3) and (4). A. R.

DISCHARGE AND OSCILLATIONS.

500. *Laws of Motion of the "Carriers" of Electricity in Gases at Low Pressures.* **H. Küstner.** (Ann. d. Physik, 63. 5. pp. 457–475, Nov. 3, 1920.)—A theoretical discussion for the case of conduction between two infinite parallel planes, one of which emits electrons, the other being maintained at a positive potential with respect to the first, less than the ionisation potential of the gas. The friction of the carriers can then be taken as proportional to their velocity through the gas. The limiting space-charge current is specially dealt with, neglecting the initial velocity of the electrons. If the friction coefficient for the carriers is made zero, the Langmuir–Schottky formula for the limiting space-charge current in a perfect vacuum can be obtained, while the Schweidler–Thomson formula for gas pressures of the order of one atmo. can be derived if the friction coefficient is large and the carriers have a velocity proportional to the field strength. [See Abs. 583 (1905).] A. W.

501. *Ionisation and Radiation in Helium.* **K. T. Compton.** (Phil. Mag. 40. pp. 553–568, Nov., 1920.)—An experimental method is described for distinguishing between ionisation and radiation [see Abs. 867 (1920)]. In helium, resonance radiation sets in at 20·2 volts and ionisation at 25·5 volts. Ionisation is observed between these voltages, in proportions increasing with the gas pressure and with the bombarding current density. Evidence is presented to show that this ionisation is a secondary effect, due to impacts against electrons which contain absorbed

radiant energy of the resonance radiation from neighbouring atoms. This method of ionisation appears to be very important at high gas pressures. A. W.

502. *Photoelectric Effect observed with Zinc Blende; further Experiments.* **B. Gudden** and **R. Pohl.** (Zeits. f. Physik, 2. 4. pp. 361–372, 1920.)—In a previous paper [Abs. 85 (1921)] it was shown that zinc blende, which in its ordinary condition is an insulator and possesses no metallic properties, will conduct electricity when light is allowed to fall on it, using a strong electric field, and that it exhibits a very marked selective action. The present paper describes further experiments with zinc blende, greenockite (cadmium sulphide), and cinnabar (mercury sulphide). All three when exposed to light in strong electric fields show conductivity which is very selective as regards the wave-length of the incident light. The increase of conductivity in the long-wave spectral region falls on or near the limits of the optical absorption bands. A. W.

503. *Photoelectric Effect in Zn and K; Effect of Absorbed Gases.* **W. Hallwachs.** (Phys. Zeits. 21. pp. 561–568, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—Describes research on the effect of absorbed gases and of gas layers upon the photoelectric effect of various substances. It was found that the photoelectric effect for zinc was very different when the metal was in an atmosphere of hydrogen, air, or carbon dioxide. The measurements were made with the gases at atmospheric pressure, and the numerical results for the three gases were in the ratio 1 : 3 : 7, while the addition of water-vapour (80 % saturation) increased the effect 2·5 times. The vapours of methyl ether, ethylene, and ammonia also increased the photoelectric effect; in the case of ammonia it was found to be five times that observed with air. By a process of successive distillations at very low pressures it was found that the photoelectric effect for potassium decreased continually, and finally a stage was reached at which the effect was reduced to only 1 % of its original value, and the selective photoelectric effect had disappeared. The results are discussed at some length and possible explanations of the phenomena suggested. A. W.

504. *Simple Demonstration of the Electrostatic Deflection and of the Charge of Kathode Rays.* **B. Walter.** (Zeits. f. Physik, 2. 3. pp. 264–267, 1920.)—The paper refers to simple electrostatic experiments with kathode rays, a special type of 3-electrode tube being employed for the purpose. A. B. W.

505. *Influence of a Magnetic Field on the Photoelectric Effect.* **H. Dember.** (Phys. Zeits. 21. pp. 568–570; Disc., 570, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—A photoelectric cell was introduced into the gap of a Du Bois electromagnet so that the surface was perpendicular to the direction of the field. Bismuth was used as the sensitive element. It was found that with a field of 600 gauss there was a diminution of 15 % in the photoelectric current and as the field strength was increased to 6800 gauss there was a further gradual diminution, the diminution for the latter value of the field being 26·7 %. Measurements made with the field reversed in direction showed that the direction of the field made no difference.

If the cell was also subjected to the effect of an electric field the diminution of the photoelectric current was found to be less and less as the strength of the electric field was increased. Corresponding results were obtained by Hull for paramagnetic aluminium. It appears probable that there is a connection between the electrons within a metal concerned with the photoelectric effect and the electrons which are concerned with the phenomena of diamagnetism. A. W.

506. *Photoelectric Conductivity in Crystals; Variation with Wave-length of Exciting Light.* **R. Pohl.** (Phys. Zeits. 21. pp. 628-630; Disc., 630, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—A small crystal of *diamond*, very clear, and transparent to 230 $\mu\mu$, was found to exhibit a photoelectric effect in strong electric fields (16,000 volts/cm.). The photoelectric effect was found to vary with the wave-length of the exciting light, falling continuously from 260 $\mu\mu$ to about 630 $\mu\mu$, its value then being zero. The fall is at first rapid and then more gradual. Two other diamonds, which were not so clear, cut off the spectrum below 300 $\mu\mu$, and showed phosphorescence. The curve for these, connecting photoelectric effect and wave-length of exciting light, shows a sharp drop to a minimum just beyond 300 $\mu\mu$, followed by a quick rise and then a further gradual fall. Except for the kink about 300 $\mu\mu$ the curve would be practically identical with that for the clear specimen. With other crystals, such as zinc blende, cinnabar, wulfenite, a selective maximum was superimposed on the normal curve. A. W.

507. *Determination of Mobility from the Brownian Motion of a Single Particle.* **R. Fürth.** I, II, III. (Ann. d. Physik, 59. 5. pp. 409–424, Aug. 5; 60. 1. pp. 77–94, Sept. 26; and 63. 6. pp. 521–536, Nov. 16, 1920.)—*Formula based on vertical Brownian Motion inapplicable.*—In Part I of the present series of papers it is shown that for a particle sinking through a liquid, the rate of motion in a vertical direction leads to smaller values of the diffusion coefficient than the rate measured horizontally. This phenomenon appears to be general for particles of different material and varying size. All possibilities which could explain this anomaly are systematically discussed, and finally the assumption is put forward that the formula based on the vertical Brownian motion is inapplicable. A *modified formula* is consequently *evolved* and the anomaly found to disappear entirely. Observations made in a horizontal direction are found to require no such correction. In order to show that the value of the diffusion coefficient calculated from the horizontal motion leads to correct values of the mobility, the latter is computed by means of the Stokes formula from the mean velocity of fall and the Loschmidt number determined from the Brownian motion. Good agreement has been found with other measurements. All methods which use the deviations from the uniform motion of small particles for the calculation of mobility give too small values unless the correction developed in the present paper be applied.

In Part II, the Ehrenhaft experimental method was employed for producing small electrically charged mercury and oil particles moving with different mean velocities in the electric field, and the mobility was determined from the Brownian motion by the Weiss method. For one and the same particle the different values found deviate sharply from

each other, although a systematic influence of the mean velocity by the Brownian movement could not be established. The observations of Weiss and Vogl, using the same experimental arrangements for silver and gold particles, are discussed, and the same behaviour deduced from them. The mobilities so determined were compared with the results given by Stokes' procedure on the one hand and by Cunningham on the other, when the mercury particles were found to possess smaller, and the oil particles greater, mobilities than were given by the Cunningham and Stokes formulæ. When the correction derived in Part I was applied, the mercury particles gave results in agreement, while for oil particles deviations appear to be caused by gradual evaporation. The charges on the particles were calculated by known methods, and in numerous cases were found to be smaller than the so-called quantum element of electricity. No evidence was afforded of a quantum-like structure in any of the dimensions. The Weiss method was found in general to afford no conclusive data in consequence of inaccuracies introduced.

In Part III an investigation has been made to find whether the mobility of a small metallic particle moving in a gas may within definite limits be independent of the velocity and character of the movement. For this purpose small electrically charged silver spheres were observed by means of the Ehrenhaft method, and the following results established :— (1) The product eB, calculated for one and the same particle for different rising and sinking velocities in the electric field under varying field forces, is constant. (2) For rapidly oscillating motions in the alternating electric field, the product eB, calculated from the amplitude of the particle oscillation, is of the same magnitude as by method (1). (3) Since the Brownian movement possesses the character of such an oscillating motion with about the same average velocity, it is concluded that the mobility determinations from the Brownian movement of single particles by a formula free from objection leads to correct values for B. (4) When for the same particle the mobility is measured by the Brownian movement procedure and by rising and sinking observations based on a definite resistance law, then within the limits of experimental error the mobilities calculated by Brownian and Stokes' procedure are in good agreement, while throughout they are smaller using Cunningham's formula. In consequence the latter is held not to correspond to the actual relationships. (5) When the particle charges are calculated according to the three methods above, agreement is found between the Brownian and Stokes procedure, while the charge by Cunningham's formula is much smaller. The former values are all of the dimensional order of electrons, but cannot be regarded as whole multiples of a quantum element.

H. H. Ho.

508. *Arcing Voltages in Mercury Vapour as a Function of the Temperature of the Kathode.* **T. C. Hebb.** (Phys. Rev. 16. pp. 375–386, Nov., 1920.)—*Low-voltage Arcs in Mercury Vapour.*—One of the objects of this work was to study the production of the low-voltage arcs in a more uniform mercury-vapour atmosphere than had been used before. As a result of improved apparatus much more consistent results have been obtained [compare Abs. 552 (1918)]. It has been shown that there is a linear relation between the striking voltage and the current through the kathode for the larger currents. This in turn has been shown, in

the case of platinum coated with lime, to mean that the striking voltage forms a linear relation with the temperature of the kathode. The results further suggest that the difference between the potential at which ionisation takes place and the accepted ionisation potential, is directly proportional to the absolute temperature. *Results with Tungsten Kathodes.*—In line with the above it has been shown that tungsten kathodes produce lower arcs than lime-coated Pt kathodes. A striking voltage as low as 3·2 volts was obtained, the lowest for Pt coated with CaO having been in the vicinity of 4·9 volts. *Effect of Thickness of Oxide Deposit on the Kathode.*—It has been shown that the thickness has an effect on the value of the striking voltage. A thinly coated Pt kathode produced an arc at a potential as low as 6·0 volts, whereas a thickly coated one produced an arc as low as 4·9 volts. *Effect of Hot Anode.*—A hot anode used with a thinly coated Pt kathode has been found to produce a lower arc than when the anode was not heated. AUTHOR.

509. *Electric Discharge Phenomena; Terminology.* **W. Schottky.** (Zeits. techn. Physik, 1. 9. pp. 208–209, 1920.)—A brief discussion is given of various types of discharge, and suggestions are made for a new terminology for the different processes involved. A. W.

510. *Disappearance of Gas in the Electric Discharge; Carbon Monoxide.* (Phil. Mag. 40. pp. 585–610, Nov., 1920. Comm. from the Research Staff of the General Electric Co., Ltd., London.)—The research described is an attempt to determine the nature and cause of the disappearance of gas under the electric discharge at low pressure. A brief summary of previous knowledge is given. It is not yet known what parts are played by absorption by the walls and by true chemical combination; nor is it known what electrical conditions are most favourable to the disappearance. Though an incandescent tungsten filament forms part of the discharge vessel, the changes investigated are not those studied by Langmuir [Abs. 934 (1915)]. Preliminary observations showed that the disappearance was closely connected with the appearance of the glow in the vessel. The electrical conditions in which the glow appears are described briefly. In any given state of the discharge vessel it appears at a definite potential difference between the electrodes, called the glow potential. Observations are described on the relation between the glow potential and (1) the thermionic emission, (2) the pressure of the gas, (3) the nature of the gas, and (4) the form of the electrodes. Small amounts of impurities change very greatly the glow potential, especially for hydrogen. The theory of the glow is deferred for later discussion, but the general connection between the appearance of the glow and the increase of ionisation in the gas is considered. Experiments on the disappearance of carbon monoxide are dealt with.

Conclusions.—The results are discussed and explained by supposing that the glow causes a chemical change in the gas, which is reversible. The recognition of this reversibility seems necessary to explain the phenomenon. The disappearance of other gases, illustrating other types of action, will be discussed in a subsequent paper. A. W.

511. *Experiments on the Nature of Discharge of Electricity through Rarefied Gases.* **S. Ratner.** (Phil. Mag. 40. pp. 785–792, Dec., 1920.)—The present theories of the discharge of electricity through vacuum

tubes fail to give a clear and adequate representation of the phenomenon. The most obscure point is the process by which, under a certain p.d., the current begins to flow through the gas. It is usually supposed that the stray positive ions which may be present in the tube, strike against the kathode with sufficient energy to cause an electronic emission from the surface-layer of atoms of the kathode, and that these electrons, by collision with the gaseous molecules, produce sufficient ions to carry the whole current. Certain experimental facts, however, disagree with this theory. Thus, when the vacuum is sufficiently high, the potential necessary to start the discharge increases with further exhaustion of the tube, although the energy imparted to the kathode by the positive ions depends only on the potential through which they fall. There is some evidence that α-particles from radio-active substances, by impinging upon a metal target, may set free slow electrons from the surface of the target, but the energy of the α-particles is enormous compared with that of the positive ions striking the kathode in a discharge-tube. It seemed important, therefore, to investigate directly the rôle played by the positive ions in the process of the discharge, and, further, to carry out experiments with a view to a direct study of the conditions under which positive ions may, by impact with the surface of the kathode, give rise to an electronic emission from the latter. The apparatus used is described and illustrated diagrammatically.

Results.—It is shown that the initial discharge of electricity through vacuum tubes is not brought about by the impact of positive ions against the surface of the kathode. A method is described by means of which the stream of ions or electrons emitted from a hot wire in a vacuum tube may be isolated from the ions produced by collision within the tube. It is shown that positive ions impinging upon the kathode with velocities corresponding to a fall through a potential difference up to 2000 volts, are unable to liberate electrons from the surface of the kathode. A. E. G.

512. *Discharge through Bromine Vapour; Distribution of Singly- and Multiply-charged Ions.* **M. Kimura.** (Kyoto Coll. Sci., Mem. 4. pp. 151–153, June, 1920.)—The distribution of charged ions along the path of an electric discharge has been studied by many investigators. Wilson [Abs. 1669 (1900)] examined the numbers of the ions along the path of discharges, but up to the present nothing was known as to the distribution of singly- and multiply-charged ions separately. Such distribution may be examined indirectly by using a spectroscopic method, and some results thus obtained are given in the present paper. According to Stark, the emission centres of spectral lines of the spark type are doubly- or triply-charged atomions of the elements, and lines of the arc type are emitted by atomions which have lost one electron. Experiments with a low vapour-pressure of bromine gave principally lines of the spark type, showing that at low vapour-pressures the bromine atoms are ionised by the impact of kathode rays to the state of multiply-charged atomions. With discharge tubes having a diameter of about 1 cm. the relative intensities of the band and the line spectra obtained varied with the diameter of the tube, the intensity of the band spectrum increasing relative to the other with wider tubes. The lines of the line spectrum were of the arc type, so that under these conditions there are numerous emission centres which have lost an electron. Besides these, there are

the emission centres for the band spectrum, probably moleculions. Increasing the current density and potential gradient was found to result in the production of multiply-charged ions, as evidenced by the change in the nature of the spectrum. A. W.

513. *Electric Figures on Crystal Surfaces.* **K. Przibram** and **[Miss] E. Kara-Michailova.** (Zeits. f. Physik, 2. 4. pp. 297–298, 1920.)—Describes the phenomena observed with a high-potential discharge from either a positive or negative electrode to the surface of a large crystal plate of gypsum, the plate being cut parallel to a plane of symmetry. [See Abs. 555 (1918) and 1168 (1920).] A. W.

514. *Pressure Differences in Discharge Tubes.* **F. Skaupy.** (Zeits. f. Physik, 2. 3. pp. 213–217, 1920.)—The increase of pressure at the anode in electric discharges through the rare gases [Abs. 630 (1919)] is shown by experiments now described to be attributable to elastic electron impacts, and a simple relation is deduced between the pressure increase and the strength of the electric field. A. W.

515. *Photographic Method of Finding the Instantaneous Velocity of Spark Waves.* **A. L. Foley.** (Phys. Rev. 16. pp. 449–463, Nov., 1920.) —*The velocity of explosive sound waves,* determined by early investigators, is briefly discussed, particularly the several experiments of Mach and his associates on the velocity of spark waves.

A New and Direct Photographic Method for Finding Spark-Wave Velocity.—A shadow of a sound wave produced by an electric spark near the centre of a long light-tight rectangular box was cast on a dry-plate at one end of the box by the light from a properly timed spark at the other end. A notched-rim steel disc was rotated at a high and measured speed just in front of and parallel with the dry-plate, the shadow of the disc covering but a narrow strip along one edge of the plate. Both the sound and light sparks cast notch shadows on the plate, the distance between the two shadows of the same notch giving the time interval between the sparks, and the sound-wave picture the distance traversed by the wave in that interval. Plotting distance against time, the tangent to the curve at a given point gives the instantaneous velocity of the wave at that point. The formula used in calculating time intervals is derived and discussed.

Velocity Almost Normal Except near the Spark.—Measurements were made on 280 plates, for waves from 0·32 cm. to 50 cm. in radius, for both heavy and thin sparks, and for disc edge speeds of almost 200 m. per sec. A wave velocity double the normal at 0·32 cm. from the spark axis decreased very rapidly with increasing distance and at 2 cm. from the source was only slightly above normal. At points relatively near the spark where the intensity of the expanding wave was still great, the velocity of waves from heavy sparks was greater than that from thin sparks. Reference is made to corroborative results obtained by the author when using two other photographic methods.

Sources of Error in Previous Investigations Eliminated by the Photographic Method.—Previous investigators have found average and not instantaneous velocities. Since the velocity very close to the source is very high, average velocities run high. However, previous results have been entirely too high due to errors inherent in the experimental methods

used. Attention is directed to several, the chief one being the use of tubes or "canals." The paper gives a photograph of a sound wave, a part of which has passed through a canal of the size used by Mach, the other part expanding freely into the space about the spark, showing the former wave 30 % faster than the latter—due to the lower average intensity of the expanding wave. AUTHOR.

516. *Calculation of Detecting and Amplifying Properties of an Electron Tube from its Static Characteristics.* **G. Breit.** (Phys. Rev. 16. pp. 387–407, Nov., 1920.)—*Calculation of the Detecting Efficiency of an Electron Tube.*—The detecting efficiency of an electron tube is calculated. In the calculation it is assumed that experimental knowledge of the static characteristics of the tube is available. The constants of the circuits used with the tube are also taken as known. From these quantities the average change in the plate current for a given amplitude of impressed grid voltage is derived. The impressed grid voltage is taken to be of the form A cos ωt where A is constant. The case when A varies slowly is also discussed.

Calculation of the Input Impedance of an Electron Tube.—The input impedance of an electron tube is calculated for the case of both positive and negative grid voltages, no assumption being made as to the mathematical form of the tube characteristics.

Generalisation of the Concept of Internal Resistance and Amplification Factor.—The concept of the complex internal resistance is introduced in treating the amplification due to a single tube. This quantity is defined by $\bar{\xi}_\omega = 1/[1/r_p + 1/(1/C_2\omega)]$, where r_p is the internal resistance, C_2 the grid plate capacity, $j = \sqrt{(-1)}$, and $\omega/2\pi$ = frequency. Similarly the amplification factor is generalised.

Condition for the Vanishing of Incoming Signal.—The condition for the vanishing of the incoming signal has been worked out. For the case of zero grid current this condition is just satisfied by tubes obeying van der Bijl's relation.

It is also seen that the condition is not satisfied by the values of plate circuit constants predicted from the simple theory neglecting internal capacities. AUTHOR.

517. *Detecting Efficiency of the Single Electron Tube.* **E. O. Hulburt** and **G. Breit.** (Phys. Rev. 16. pp. 408–419, Nov., 1920.)—*Definition of Detecting Efficiency.*—As a definition of the detecting efficiency lim A^2/b_0 is taken. Here b_0 is the average change in the rectified component of the output plate current and A is the amplitude of the input grid potential.

Derivation of Theoretical Formula.—A theoretical formula is derived for the detecting efficiency.

Measurement of Detecting Efficiency.—Measurements of detecting efficiency were carried out by means of a *condenser potential-divider* and a sensitive *quadrant electrometer.*

Verification of Theory by Experiment.—By the measurements performed the theory has been verified qualitatively. An attempt to verify the theory quantitatively showed the necessity of taking into account the capacities between the tube elements.

Application to Armstrong's Tuned Plate Circuit.—The sudden drop

in signal strength observed with Armstrong's circuit has been explained by the above theory. AUTHORS.

518. *Rotation of the Plane of Polarisation of Electromagnetic Waves.* **K. F. Lindman.** (Ann. d. Physik, 63. 7. pp. 621–644, Dec. 1, 1920.)—*Experimental Method.*—A description is given of the experimental investigation of the rotation of the plane of polarisation of electromagnetic waves by an isotropic system of spiral-shaped resonators. These resonators were made from copper wire 9 cm. long and 1·2 mm. diam., and were bent into spirals of 10 mm. diam. and about 7 mm. long, each spiral having about 2½ turns. The spiral resonators thus made were rolled up in cotton so that each was in the centre of a little cotton ball. The balls were then introduced into a cardboard cylinder with a diam. of about 25 cm., the balls being arranged at random. One such tube had 300 left-handed spirals, another 200 similar ones, and a third had 200 right-handed spirals. An oscillator provided with a cylindrical-parabolic reflector was used to send electromagnetic waves through one or other of the tubes, and the transmitted radiation was received on a single straight resonator provided with a thermo-element. This resonator was perpendicular to the direction of the radiation and could be rotated about an axis coincident with that direction.

Results.—The results obtained with the apparatus are illustrated by a number of interesting curves. They show that a three-dimensional grating consisting of the left-handed spirals described rotates the plane of polarisation of electromagnetic waves passing through it to the left or right (looking in the direction of the beam), according as the wave-length (λ) of the waves is greater or less than that (λ_0) corresponding to the natural frequency of the spiral resonators. A system of right-handed spirals behaves in the converse manner. If λ differs very little from or is equal to λ_0, the resulting oscillation is elliptically polarised, and the angle between the major axis of the ellipse and the oscillation plane of the incident beam certainly increases when λ passes the value λ_0. The resonator system exhibits selective absorption, and the absorption maximum corresponds to a wave-length a little, but only a very little, greater than λ_0, in agreement with Planck's electromagnetic dispersion theory of light. For values of λ not in close agreement with λ_0 the angle of rotation ϕ follows the law $\phi = k_0/(\lambda^2 - \lambda_0^2)$, where k_0 is a constant. When λ_0^2 can be neglected with respect to λ^2, ϕ is inversely proportional to the square of the wave-length of the incident radiation, as in Biot's optical law. The rotation is directly proportional to the number of spiral resonators in the path of the beam, that is, to the active thickness of the grating, again in agreement with optics. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

519. *Variation with Temperature of the Conductance of Calcium Sulphide.* **P. Vaillant.** (Comptes Rendus, 171. pp. 1380–1383, Dec 27, 1920.)—The conductance of a thin layer of CaS increases rapidly with temperature to a well-defined maximum, and then falls to vanishing point. The conductance-temperature gradient and max. conductance increase with the rapidity of temperature-increase. If cooled before reaching the maximum and reheated, the gradient and the maximum are much reduced,

suggesting a close connection with phosphorescence. Quantitative results are obtainable by studying separately the instantaneous increase in the conductance c, and its rate of variation with time. Experimental results are tabulated, and where T is the temperature (° C.) and t the time, the two sets of observations are very approximately represented by the curves $c = 1{\cdot}17e^{0{\cdot}130T}$ and $c = c_0e^{-bt}$, where $T_0 = 15{\cdot}1$ and $b = 0{\cdot}00130(T - T_0)$. These are combined in a sample set of observations into the relation $c = c_0e^{\beta(T-T_0)(1-t/t_0)}$, where c_0, t_0, T_0, and β are constants having the values $c_0 = 8{\cdot}33$, $t_0 = 100$, $T_0 = 15{\cdot}1$, $\beta = 0{\cdot}130$. In general, however, c_0, t_0, and T_0 will themselves be functions of t.

G. W. DE T.

520. *A New Property of Feeble Conductors of Electricity.* **G. Reboul.** (Comptes Rendus, 171. pp. 1052–1055, Nov. 29, 1920.)—A photographic plate is placed in a closed box, through the cover of which two electrodes insulated with ebonite are passed; upon the plate is placed a sheet of paper, and the electrodes, having a difference of potential of 1000 volts, rest on this paper. After an exposure varying from 24 to 48 hours it is found, on developing, that the fibres of the paper are reproduced on the negative and the lines of equipotential are also roughly shown. The impression obtained depends upon the kind of paper used, those papers with a grain giving a granular impression which makes the equipotential lines less easily seen. The effect is not due to the action of a shunt current upon the emulsion forming the sensitive layer of the plate, for if the sheet of paper is removed the photographic impression is localised in the neighbourhood of the electrodes. Neither is it due to simple mechanical action, nor to the presence alone of the paper, for the suppression of the p.d. between the electrodes makes it disappear. If the conductivity of the sheet is increased the impression on the plate is very marked. It is necessary that the body shall be a conductor, but it may be only feebly conducting; a metallic layer when used in place of the paper fails to produce the result. It appears that the physical constitution of the paper plays an important part; in general the effect is more marked with papers of coarse grain or fibre than with those of fine grain; with glazed paper the effect disappears, except in the neighbourhood of the electrodes. If the heterogeneity of the paper is increased by making superficial incisions upon it, the impressions are most marked in the neighbourhood of the incisions. Experiments are described which tend to prove that the condition of the surface of paper affects the results obtained. The same experiments may be made with other poor conductors, such as celluloid, wood, glass, mica, quartz, etc.

A. E. G.

521. *Specific Inductive Capacity (Dielectric Constant) of Water.* **M. Sauzin.** (Comptes Rendus, 171. pp. 164–167, July 19, 1920.)—Gutton and Touly's 3-electrode valve short-wave generator [Abs. 476 (1919)] was employed by the author for measuring the specific inductive capacity (dielectric constant) of water. The circuit was formed of a pair of parallel copper wires 1·5 mm. in diam. and 8 cm. apart, bridged at each end. The bridge distant from the generator contained an iron-constantan couple of 0·5-mm. wire, with a galvanometer connected across it, while the near bridge, containing a 0·004-mfd. condenser, was placed parallel to a side of the generating circuit. This capacity sufficed for the complete transmission of the waves employed, namely, between 444 cm. and 242 cm., and

prevented short-circuiting of the thermoelectric couple. For non-resonant wave-lengths the galvanometer remained practically undisturbed, but in resonance it was delicate enough to determine the wave-lengths to within about a millimetre. Adjustment was effected by making the terminals of the distant bridge in the form of brass tubes sliding on the parallel wires. When tuned to resonance the sensitiveness was such that the approach of a sheet of paper to the circuit produced a visible effect. A portion of the circuit most remote from the generator was then enclosed within a box of paraffined wood, 15 cm. in depth and in breadth, shown to be sufficient by the null effect of approaching a sheet of metal to the outside of the box. To avoid the setting up of a supplementary system of stationary waves by reflection at the entry point of the circuit into the water, this was arranged to take place at a node. At this point a third bridge containing a second condenser of the same capacity as before was thrown across, the point being determined by its being a maximum point of oscillation intensity for the then length of waves in the circuit, which fixed it within a millimetre. The dielectric constant K was then the quotient of the resonance wave-length of propagation in air by that in water. A comparison of the intensities of oscillation for the two wave-lengths gave the coefficient of damping due to the conduction of the water. But the damping was too small to serve for determining the conductivity with any exactness. With waves of from two and a half to four and a half metres in air, the damping coefficient ranged from about 0·003 to 0·004, in the case of distilled water, with a value K = 73 as the mean of several determinations. In the case of water from the Moselle, drawn from the conduits in Nancy, the damping coefficient was 0·007, giving K = 75. The author accounts for the smallness of these numbers, as compared with the usually accepted value of 80, as being partly due to the great precision of the method employed, and also in part to the weakness of the fields possible to this method. For there appears reason to suppose that K is not independent of the field intensity, and the author points out that this question may be further investigated by using the present method with still weaker fields. G. W. DE T.

522. *Calculation of the Self- and Mutual Inductance of Coils.* **G. W. O. Howe.** (Radio Rev. 1. pp. 763–768, Dec., 1920.)—Esau has published various papers dealing with the calculation of the inductance of coils of various types [Abs. 434 and 743 (1920)]. In the present paper tables are given of the values of the various coefficients appearing in Esau's formulæ, so that reference to the original papers is not required for numerical calculations. The cases dealt with are: (1) Single-layer coil on square frame. (2) Square plane or pancake coils. (3) Multi-layer coils of circular section. A. W.

523. *Further Measurements of the Effect of Pressure on Resistance.* **P. W. Bridgman.** (Nat. Acad. Sci., Proc. 6. pp. 505–508, Sept., 1920.)—In a previous investigation data for the effect of pressures up to 12,000 kg./cm.^{2} on the resistance of 22 metals were given. It has now been possible to extend the results to 18 more elements, and 6 alloys. *Modified Method.*—The extension has been made possible by two changes in the technique. In the first place, by a change in the method of leading electrical connections into the pressure chamber it has been possible to replace the previous method of measuring resistance with a Carey Foster

bridge by a potentiometer method. This makes it possible to measure accurately specimens whose total resistance is very low, and removes the restriction that the specimen must be in the form of a fine wire. In the second place, by a modification in the design of the apparatus it has been possible to extend the temperature range considerably. The results now cover a range from atmospheric to 12,000 kg. pressure, and an extreme temperature range from 0° to 275° C. In selecting the substances to be measured over this increased range, particular attention has been paid to liquid metals. Previously the effect of pressure on both liquid and solid state was not known for a single metal, and the absence of crystalline structure in the liquid state introduces no complications.

Three New Elements showing a Positive Pressure Coefficient of Resistance.—Six elements have now been investigated in the liquid and solid states. Some of the more unusual elements were tested, resulting in the discovery of three more elements, Li, Ca, and Sr, which have a positive pressure coefficient of resistance; bismuth and antimony were the only ones known previously. A number of commercial alloys are also included.

Results.—The results are tabulated and discussed. The substances with negative pressure coefficients are Na, K, Mg, Hg, Ga, Ti, Zn, As, W, La, Nd, Si, and black P. *Sodium and potassium* are *the first alkali metals whose pressure coefficients have been measured,* the results being larger than for any other metals as yet investigated. The pressure coefficient of these metals decreases greatly with increasing pressure and increases with increasing temperature, and the temperature coefficient decreases with increasing pressure. Liquid Bi is found to be negative and normal, although that of the solid is positive and abnormal. This points to the importance of crystalline structure in determining the variations of resistance. On the other hand, Li is abnormal in being positive in both liquid and solid states. It seems to be universally true that the temperature coefficient of the liquid is less than that of the solid, and the change of resistance on melting is in the direction of the change of volume. It is probable, because of the peculiar nature of the atomic structure of lithium and the fact that its pressure coefficient of resistance is positive, that the picture of the mechanism of electrical conduction given by Wien and Lindemann as a space-lattice of electrons sliding in the channels of a space-lattice of atoms may have much of truth for this particular element. The new evidence does not necessitate a modification of the previous standpoint that for most elements the most important single factor in determining the variations of electrical resistance is the amplitude of atomic vibration. H. H. Ho.

524. *Effective Capacity and Resistance of a Condenser for High-Frequency Currents; Non-dependence of Capacity upon the Frequency.* **F. C. Blake.** (Phys. Rev. 16. pp. 540–557, Dec., 1920. Paper read before the Am. Phys. Soc., Nov., 1919.)—By careful experiments on the free oscillations of a Lecher system as the capacity of the end condensers is changed by increasing the elastic coupling it was found that the capacity of an air condenser is independent of the frequency of oscillation.

Rayleigh's equation for the effective stiffness (elastance) of a circuit due to the mutual elastic reactions between two circuits, each containing inductance, capacity and resistance, was verified. Use is made of this equation for effective resistance to determine the mutual resistance of two reacting circuits. A. W.

525. *Contact Electricity; E.M.F. due to Film of Moisture between Two Metals.* **H. Rohmann.** (Phys. Zeits. 21. pp. 699–703, Dec. 1 and 15, 1920.)—The e.m.f. resulting from the film of moisture on two metal electrodes was investigated for a number of different metals, and the conclusion is drawn that at the surface of metals two different feebly conducting layers exist, an inner one which is concerned with microphonic phenomena, and an outer one to which is due the e.m.f. of the Volta-effect. It was found that a platinum–silver contact affected by a film of iodine gives a marked rectification. The resistance ratio is greater than 10^6. [See Abs. 1323 (1920).] A. W.

526. *Resistances with Backward-turning Temperature Characteristics.* **H. Busch.** (Phys. Zeits. 21. pp. 632–634, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—This paper gives a theoretical discussion of the behaviour of iron-wire resistances in an atmosphere of hydrogen. As the voltage is increased the current through the wire increases at first gradually, then decreases slightly and remains almost constant for a considerable increase of the applied voltage, after which it increases again more gradually. Actual curves for different pressures of hydrogen are given. These are seen to be all of the same nature, and agree very well with the curve deduced theoretically. A. W.

527. *Weston Cell containing Acid Electrolyte.* **J. Obata.** (Phys. Math. Soc. Japan, Proc. 2. pp. 232–236, Dec., 1920.)—It has been pointed out by F. E. Smith that the constancy of a Weston cell is better secured if the electrolyte is made acid. The author has prepared several cells containing electrolyte acidified to various strengths and studied their properties. The e.m.f. decreases linearly as the acidity increases, the acidity-electromotive relation being found to be $\Delta e = 85{\cdot}5\,x$, where Δe is the decrease in voltage expressed in 10^{-5} volt, and x the acidity of the electrolyte expressed in terms of normal acidity. Smith observed that when the solution of cadmium sulphate is made up from normal acid saturated with cadmium sulphate the e.m.f. is diminished by 0·000 65 volt. The author's results are in exact agreement. After the acid cells have attained their normal value they are found to be extremely constant. The temperature coefficient of a cell containing 0·76 N-acid is greater than that of the non-acid cell by 11 per cent. F. E. S.

528. *Copper Standard Cell.* **J. Obata.** (Phys. Math. Soc., Japan, Proc. 2. pp. 223–229, Nov., 1920.)—Standard cells were made with mercury as the anode, copper amalgam as kathode, copper sulphate solution as electrolyte, and mercurous sulphate as depolariser. The mean e.m.f. of ten such cells was found to be $0{\cdot}3497_9$ int. volt. The reproducibility appears to be good, but there is a tendency for the e.m.f. to fall with time. The temperature-e.m.f. relation was found to be $E_t = E_{20} - 0{\cdot}000\,635\,(t - 20) - 0{\cdot}000\,0024\,(t - 20)^2$. F. E. S.

529. *New Kind of Resistance of Higher Ohmic Value.* **F. Skaupy** and **H. Ewest.** (Zeits. techn. Physik, 1. 8. pp. 167–169, 1920.)—This resistance consists of specially arranged layers of graphite on an insulating support. In order to shield the resistance from injury it is enclosed in a

glass bulb which is filled with rarefied hydrogen in order to cut out the effect of heat. Three diagrams of model resistances are given. The method has been tested for resistances of $3{\cdot}6 \times 10^3$ ohms, 14×10^3 ohms and 33×10^3 ohms. After cooling, these resistances are tested with smaller currents and it is found that they return to their normal values. A table of temperature coefficients is given for temperatures 20° to 45° and 45° to 70°. The resistances were also tested with alternating current; they showed no measurable shift of phase. A. E. G.

530. *Simple Gold-Leaf Electroscope.* **E. A. Owen.** (Röntgen Soc., J. 16. pp. 149–150, Oct., 1920.)—A description is given of a robust gold-leaf electroscope adaptable for α, β, γ, or X-ray measurements. An interesting method of insulating the leaf system by means of a compound ebonite and sulphur plug is described. A. B. W.

531. *Portable Electric Magnetometer.* **N. Watanabe.** (Phys. Math. Soc. Japan, Proc. 2. pp. 210–223, Nov., 1920.)—A description is given of an instrument by means of which the horizontal intensity may be determined from observations of the deflection caused by a current in a coil of known constant. The current is produced by a dry battery and is measured by a potentiometer method using a standard cell, delicate galvanometer, and standard resistance; the current employed was 10 milliamps. The form of coil adopted was a double Helmholtz coil of diam. 13·2 cm., containing 14 layers each of 13 windings on a cast duralumin frame. This was made to fit on to the theodolite of a Tanakadate magnetometer with mirror and a needle 3 mm. long. The conductors leading from the coils are coaxial, to do away with their magnetic effect. The two coils are in series, but by means of a commutator may be put in opposition; another commutator reverses the field at the centre. A series of observations, in which the sine method is used, was carried out at the Hydrographic Office, and gave a value of H about 20γ higher than that obtained by the Gauss-Lamont method. The instrument is provided with another mirror, at right angles to the first, by means of which declination may be determined. A standard Helmholtz coil with one winding was made, and details are given of its dimensions, properties, and constants. Using the standard coil in a comparative test, the electrical constant of the portable coil is found to be about 24·7 c.g.s. per ampere, the exact value being given in terms of the temperature.
G. E. A.

ALTERNATING CURRENTS AND MAGNETISM.

532. *Quantum Theory and the Magneton; Magneton Numbers for NO and O.* **W. Pauli, Jr.** (Phys. Zeits. 21. pp. 615–617, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscher Versamml., Nauheim, Sept., 1920.)—The first part of this paper discusses the Bohr and the Weiss magneton, the latter having a value about one-fifth that of the former. The author is inclined to regard the Weiss magneton as having no reality. The second section deals with Langevin's formula, and the third with molecules and heat rotation. Magneton numbers are calculated for NO and for O_2 and show close agreement with observed values. It is concluded that oxygen has a bi-quantic and NO a uni-quantic magnetic moment perpendicular to the axis of figure. It is thus probable that the neutral oxygen atom possesses a uni-quantic moment, and that in the

oxygen molecule two oxygen atoms are so arranged that their moments do not compensate one another, but add together. It is also probable that the atoms in the NO molecule are uncharged. A. W.

533. *Determination of Susceptibility of Water by Ascent of Water Column Method.* **A. Piccard** and **A. Devaud.** (Arch. des Sciences, 2. pp. 455–485, Nov.–Dec., 1920.)—The paper contains an introduction and three chapters. In the introduction, previously found values of the susceptibility of water are given from Quincke's, namely $-0{\cdot}8 \times 10^{-6}$, to those of Lève, Piccard, and de Haas and Drapier, which vary by several parts per thousand.

Method.—The first chapter deals with the experimental method which is that of the measurement of the ascent of a water column in a strong magnetic field. The authors seek to attain an accuracy of 0·5 per 1000. In measuring the magnetic field intensity, which is of the order 24,700 c.g.s., the following principle is employed: the field H is measured by an electrodynamical method which gives H in the form $a \div i$; it is next measured by an induction method for which $H = bi$; from the two $H = \sqrt{(ab)}$, an expression which is independent of the current i. The measurement of the rise of the water, which is about 2¼ mm., is done by means of a Piccard tube [Abs. 1, 518, 519 (1913)].

Results.—The second chapter deals in detail with partial results, errors and corrections; in the last chapter the final result is calculated, namely $-0{\cdot}71992 \times 10^{-6}$ for the coefficient of magnetisation at 20° C., and $-0{\cdot}71864$ for the susceptibility at the same temperature. G. E. A.

534. *Magnetisation of Gases, and the Magneton; Oxygen and Nitric Oxide.* **E. Bauer** and **A. Piccard.** (J. de Physique et le Radium, 1. pp. 97–122, Oct., 1920.)—The gases dealt with were the two paramagnetic gases, oxygen and nitric oxide. The principle of the method was to measure, in turn, the change of level of water in a tube when subjected to a magnetic field in an atmosphere of hydrogen and then in the gas under test. Hydrogen is so feebly diamagnetic that its magnetisation is negligible, and the change of level in this gas is due simply to the repulsion of the water by the field. In a magnetic gas, the change of level measures the repulsion of the water added to the attraction of the gas.

Two *methods of measuring* were employed: in the second, an O-tube was substituted for a U-tube; this enabled the experiment to be continued for a long time without changing the water. The fact thus emerged that the solution of gas in the water causes an error, the susceptibility being always too small.

Results.—The values obtained were: for oxygen $(107{\cdot}8 \pm 0{\cdot}3)10^{-6}$, and for nitric oxide $(48{\cdot}7 \pm 0{\cdot}25)10^{-6}$. The numbers of magnetons, calculated by the usual method, were 7·08 and 9·20 for O_2 and NO respectively.

Conclusion.—A theoretical discussion, based on the probable value of the moment of inertia of the oxygen molecule, leads to the conclusion that Reiche's theory of magnetism, founded on Planck's second hypothesis of quanta, appears to be in poor agreement with the results of Kamerlingh Onnes and his collaborators. [See also Abs. 88 (1919).] G. E. A.

535. *Is the Atom the Ultimate Magnetic Particle?* **A. H. Compton** and **O. Rognley.** (Phys. Rev. 16. pp. 464–476, Nov., 1920.)—*Effect*

of Magnetisation of Crystal on Intensity of X-ray Reflection; Theory.—The intensity of reflection of X-rays from a crystal depends upon the arrangement of the atoms within the crystal and upon the arrangement of the electrons within the atom. If the ultimate magnetic particle is a group of atoms, such as the chemical molecule, magnetisation of the crystal will change the orientation of the group and hence change the positions of the individual atoms. If the ultimate magnetic particle is the atom, magnetisation will change the orientation of the atom and thus alter the arrangement of the electrons. In either case magnetisation of a crystal should be accompanied by a change in the intensity of a beam of X-rays reflected from its surface.

Effect of Magnetisation of Crystal on Intensity of X-ray Reflection; Experiment.—Such an effect was sought for by reflecting X-rays from a crystal of magnetite and measuring the intensity of the reflected beam by a sensitive balance method. The test was made on the first four orders of reflection from the natural (111) face when the crystal was magnetised perpendicular to its reflecting surface and on the third order when magnetised parallel with this surface. On magnetising the crystal to 1/3 of saturation and on demagnetisation, no change in intensity of the reflected beam was observed, though a variation of 1 % would have been detected.

Molecule as Ultimate Magnetic Particle.—A displacement of the atoms due to magnetisation by 1/300th of their distance apart would have produced a detectable effect. This experiment therefore affords a strong confirmation of the conclusion reached by K. T. Compton and E. A. Trousdale that the elementary magnet is not a group of atoms [see Abs. 919 (1915)].

Motion of Elementary Magnet in Strong Magnetic Field.—An argument is presented which shows that when saturation occurs the elementary magnets very probably have their axes nearly parallel with the direction of magnetisation.

Atom as Ultimate Magnetic Particle.—Subject to the validity of this conclusion, it is not found possible to explain the negative result of the experiment if the atom as a whole acts as the elementary magnet. Certain other explanations are also discussed and found unsatisfactory.

Electron or Positive Nucleus as Ultimate Magnetic Particle.—Either of these conceptions is in accord with the result of the experiment, but auxiliary evidence favours the electron as the probable elementary magnet.

AUTHORS.

536. *The Kinetic Theory of Magnetism; Susceptibility of Gases.* **W. Weaver.** (Phys. Rev. 16. pp. 438–448, Nov., 1920.)—*Magnetic Susceptibility of Gases.*—The results of a previous paper by Honda and Okuba [Abs. 85 (1919)] are considered, certain important errors noted, and some aspects of the assumptions further examined and developed. The susceptibility is not the same whether or not the gyroscopic nutation of the molecules persists, and the apparent agreement with Langevin's result is shown to be in error. A gas is shown to be diamagnetic or paramagnetic, on this theory, according as the nutation does or does not persist. The result holds, at least without further investigation, only for smooth spherical molecules rather than as stated. A discussion is given of the effect of thermal impacts on gyroscopic motion of this type.

AUTHOR.

537. *Thermal Variation of Magnetisation of Anhydrous Sulphates and the Magneton.* **P. Théodoridès.** (Comptes Rendus, 171. pp. 715–717, Oct. 18, 1920.)—Observations were made on the substances $MnSO_4$, $CoSO_4$, and $Fe_2(SO_4)_3$, powders of these salts being tested, by the method of attraction in a non-uniform field, at various temperatures produced by an electric furnace. Results are given for the Curie constant, the critical temperature, the molecular field constant, and the number of magnetons. The respective numbers of the latter in the above sulphates are 29, 25, and 29. The molecular field is negative in all three salts, and the Curie point is below absolute zero. G. E. A.

538. *Thermal Variation of the Coefficient of Magnetisation of Chlorides and an Oxide in the Solid State, and the Magneton Theory.* **P. Théodoridès.** (Comptes Rendus, 171. pp. 948–950, Nov. 15, 1920.)—The methods previously employed are now applied to manganous, cobalt and nickel chlorides and to manganous oxide. For cobalt and nickel chlorides, the results obtained for the thermal variation of the coefficient of magnetisation are in conformity with the magneton theory. On the other hand, the numbers obtained for n, the number of magnetons, in the case of manganese chloride and oxide are fractional, although the differences between the magnetic moments are very near to one magneton. Contrary to what was found with the sulphates [see preceding Abs.], the constant of the molecular field is positive for all the above chlorides, the sign of this constant apparently depending on the nature of the union of the compound and not at all on its action. Thus with the chlorides the existence of a real Curie point is to be assumed at very low temperatures.

T. H. P.

539. *Magneto-Crystalline Properties of Indian Braunites.* **K. S. Rao.** (Indian Assoc. for Cultivation of Science, Proc. 6. 1 and 2. pp. 87–94, 1920.)—Braunite is a natural ore of manganese which occurs in great abundance in various parts of the country, and which is invariably slightly magnetic. Two specimens from Kacharwahi and Kandri were ground into spheres of respective densities 4·8 and 4·22. The average intensity of magnetisation was calculated from the pull experienced by the specimen in the non-uniform field of a powerful electromagnet. The max. field used was about 4000 gauss and the susceptibility was $0{\cdot}4 \times 10^{-3}$. The specimens have a magnetic axis of symmetry with a perpendicular plane in which the susceptibility is independent of orientation. Along the axis of symmetry the susceptibility is a minimum, and in the plane it is a maximum, the difference being about 2 %. G. E. A.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

540. *Rate of Chemical Action in the Crystalline State.* **C. N. Hinshelwood** and **E. J. Bowen.** (Phil. Mag. 40. pp. 569–578, Nov., 1920.)—Investigations have been made of the course followed by the decomposition, at temperatures below their melting-points, of potassium permanganate, solid solutions of potassium permanganate and perchlorate, ammonium dichromate, and tetranitroaniline. Crystals of different sizes were employed, and the reactions were followed by measuring the volume or the pressure of the gaseous products.

The reaction appears to be confined to those molecules of the crystalline compound which are in the neighbourhood of the surface, the change being greatly accelerated where progressive disintegration of the crystal structure takes place. Solution in another solid causes a reduction in the rate of reaction.

It is evident that the molecules in the interior are under restraint of some kind, owing either to the fact that these molecules are bound by valency forces on all sides or to the internal pressure. T. H. P.

541. *Kineto-Electromagnetic Theory of Crystals.* **J. Beckenkamp.** (Physik. u. Med. Ges. Würzburg, Verh. 5. pp. 135–163, 1918. Chem. Zentrbl. 1919. i. p. 273).—This is an extension of Bohr's theory on general electromagnetic arguments, differing also as to the valency conception. The four nuclei of the helium atom occupy the corners of a tetrahedron (by reason of repulsion), each face of which contains the path of an electron; the four normals constitute magnetic axes forming an astatic system; the atom hence shows no external field and is electrically neutral. The lines connecting the centres of gravity of atoms united by valencies form polar electric axes. In all regular crystals the chemical molecules are arranged in a fourfold cube lattice, consisting of four interlocked cube lattices, in each of which the electric axes are directed towards similar tetrahedron normals. The metals Cu, Ag, Au, Pb, Al form monatomic molecules; carbon has diatomic molecules, As, Bi, Sb, W tetratomic molecules. In other cystals the astatic system is built up in other ways. H. B.

542. *Collective Crystallisation and the Atomic Field of Crystals.* **R. Gross.** (Jahrb. d. Radioakt. 15. pp. 270–292, Nov. 28, 1918.)—By "Sammelkristallisation" the author understands the apparent growth of large crystals at the expense of small crystals in contact with them or in the same solution or vapour, without there arising any modifications, a kind of isothermal distillation. The assumption that crystal growth leads to the production of forms, for which the specific surface energy is a minimum, presupposes that this energy of a crystal face is independent of the area of the face and of the concentration of a solution; this is untenable. With J. Stark the author replaces this surface energy by a complicated action of the "molecular field," after Grandjean and P. Weiss. The first example dealt with is the formation of tungsten crystals in the filaments of lamps by the Pintsch process. The particles of fine powder are further

reduced in size by grinding, and then mixed with a binder and 1 or 2 per cent. of thoria (this addition being merely a matter of experience); the filament (produced with the aid of dies) is drawn through a short, small spiral of tungsten wire, heated to about 2200°, at the rate of 0·06 cm. per sec. The particles then crystallise, much below the melting-point; the grouping of the atoms in the particles is not altered by the crystallisation (Debye and Laue). A similar crystallisation takes place in nitrogen-filled lamps. Other examples discussed are the crystal-developments in re-heated metals (Cu, Fe), in silver sols, in powdered calcium carbonate under pressure (marble formation, Becker, 1886), in solution and in vapours. Small particles are more soluble than large ones, which is explained by the molecular-field theory. H. B.

543. *Experimental Investigation of Crystal Structure by Röntgen Rays.* **R. Gross.** (Jahrb. d. Radioakt. 15. pp. 305–329, May, 1919.)—Discussion of the methods of Bragg, Laue, and Debye and Scherrer, and of the calculations based upon them. The last-mentioned method in particular shows that amorphous substances are really crystalline; there are probably only liquids and solids, differing in viscosity. H. B.

544. *Derivation of the Periodic System of Elements from the Electron Theory.* **H. Teudt.** (Zeits. anorg. Chem. 106. pp. 189–208, May 20, 1919.)—The author accepts the nucleus of Rutherford and Stark, and distinguishes an inner sphere of electrons firmly held by the nucleus and an outer sphere of valency electrons, which bind the atoms to molecules. The only electron of hydrogen is a valency electron. Helium and the other inert gases have only inner electrons. In the other elements the electrons are of both kinds; in elements of variable valency some electrons become retained in the inner sphere. The valency electrons of metals are more mobile than those of metalloids. As we pass from left to right in a horizontal series, the number of positive charges increases, whilst the number of electrons remains constant, their rotational velocity increasing; hence the metalloid character increases in that direction. As all the elements of the 3rd, 5th, 7th series are metallic, it is suggested that in their case the inner sphere consists of an odd number of rings of electrons, the central ring being equatorial and intercepting the lines of force which in series 2, 4, 6, would bind the valency electrons more firmly. With increasing numbers of electrons the valency-binding becomes weaker and the metallic character more pronounced. H. B.

545. *Estimation of the Size and Structure of Colloidal Particles by Röntgen Rays.* **P. Scherrer.** (Ges. Wiss. Göttingen, Nachr. pp. 96–100, Sept. 26, 1918. Chem. Zentrbl. i. pp. 322–323, 1919.)—In the determination of the structure of organic and inorganic colloids after Debye and the author [Abs. 1130 (1916)] the single colloid particle may or may not have a crystalline structure. In the former case the position of the interference bands would not depend upon the size of the particles, but the breadth of the bands would depend upon the size. In the absence of crystalline structure there would be no distinct bands but only maxima and minima in the region of the incident rays, and the interpretation becomes more difficult. In gold and slver colloids the author finds crystalline particles fitting into the space-lattice of

macroscopic gold particles; even the smallest particles seem to indicate the same space-lattice. The dimensions agree with those deduced from the ultra-microscope or osmotic measurements. In the aged gels of silica and stannic acid, previously observed, crystallisation is proceeding. Typical organic colloids (albumen, casein, gelatin, cellulose, starch), seem to be really amorphous and to consist of irregularly oriented molecules or groups of molecules. H. B.

546. *Theory of Electrolytic Ions.* X. *Conductivity of Multi-valent and Multi-Stage Electrolytes.* **R. Lorenz.** (Zeits. anorg. Chem. 106. pp. 49–75, April 24, 1919.)—An attempt to develop a general theory of electrolytic dissociation starting from Planck's conductivity equations. All figures are referred to molar quantities, and the terms of normal solutions and equivalent conductivity are avoided as misleading. In a single-stage dissociation the dissociation takes place only according to one formula, though there may be more than two ions. Only in this single-stage dissociation will the molecular conductivity quotient μ/μ_∞ be identical with the degree of dissociation which is simply the ratio of the dissociated to the original number of molecules. In multi-stage dissociation this quotient bears no direct relation to the degree of dissociation and is generally smaller than the latter. H. B.

547. *Molecular Heats at Very High Temperatures.* **H. v. Wartenberg** and **G. Witzel.** (Zeits. Elektrochem. 25. pp. 209–212, July 1, 1919.)—When we burn in a bomb calorimeter a weighed mass of metallic magnesium in oxygen in the presence of some MgO, the new oxide formed will fuse or not according to the proportion of the MgO already present. By increasing this proportion until fusion just fails to be attained, we can estimate the mean specific heat of magnesium oxide up to its melting-point. Instead of adding only MgO we may use mixtures of this oxide with finely-divided platinum and iridium, melting-points 1755° and 2390°, and then estimate the specific heat up to the respective melting-point. The authors find the determination of the critical proportions difficult; the fused mass may form a smooth cake or be lumpy or a sandy powder. The upper limits of specific heats (at temperatures up to 3000° abs.) thus estimated may be correct within 10 or 20 %, and the figures agree with the values extrapolated from curves up to 1600°. Some of the values found for the true molecular heats are: MgO, at 415° abs. 10·2 cals., at 1683° 14 to 15; CaO, at 559° 11·6, at 1369° 12 to 15; Al_2O_3, at 230° 10·8, at 1308° 28 to 30 cals. H. B.

548. *Atomic-Weight Determinations: Thorium-Lead and Scandium.* **O. Hönigschmid.** (Zeits. Elektrochem. 25. pp. 91–97, April 1, 1919.)—Determining the ratios $PbCl_2 : 2\,Ag$ and $PbCl_2 : 2\,AgCl$, the author found Pb$_{Th}$ from thorite 207·91 (in two experiments), the highest value ever found for Pb. Other ores gave slightly smaller values. The author concludes that there is probably a lead isotope 208·1 and that ThD is not stable, but has a very long life. As regards scandium, different experimenters all using the sulphate method differ sufficiently (Sc 44·0 to 45·2) for doubt to be thrown on the reliability of the method. The author takes the bromide prepared by heating the oxide in a quartz tube with bromine and carbon and subliming the bromide for purification at 1000°; the bromide does not melt then, but attacks the quartz slightly.

The two mineral specimens used were absolutely pure, Haschek not even detecting the persistent ytterbium line. The mean of 18 determinations is Sc = 45·099 ± 0·014, so that the at. wt. 44·1 so far accepted should be raised to 45·1. H. B.

549. *Triatomic Nitrogen N_3.* **M. Trautz.** (Zeits. Elektrochem. 25. pp. 297–300, Sept. 1, 1919.)—Thermochemical considerations to show that the active nitrogen of Strutt and of Koenig consists partly of N_3 at ordinary temperature, and that N_3 predominates at low temperatures. The reaction velocity of N_3 is very high, its heat of formation hence very small, and it will be impossible to prepare the N_3 pure by merely thermal methods. On cooling it reacts with N to form N_2, and on heating it decomposes into N and N_6; this latter N_6 must be present in the gas at very low temperatures, though in very small quantities. The luminescence is explained by the author's views on the proportionality between reaction velocity and brightness. Constitutionally N_3 is probably an open-chain compound, analogies of which should occur in Cl, Br, I and O, but not in H. The triatomic oxygen would be an isomeride of ozone. H. B.

550. *New Periodic Classification of the Elements.* **M. Chauvierre.** (Soc. Chim., Bull. 25. pp. 297–305, July, 1919.)—When the atomic weights are plotted as abscissæ and the principal valencies (0, 1, 2, 3, 4) as ordinates, a series of inverted V curves is obtained. The elements of the iron, palladium, platinum, didymium groups rise in less distinct curves into regions of higher valencies. The curves show the group character and the double periodicity, and the classification may be developed into an inorganic evolution theory. H. B.

551. *Attack of Platinum and Gold by Caustic Alkalies, etc.* **L. Quennessen.** (Soc. Chim., Bull. 25. pp. 237–240, May, 1919.)—Comments upon the paper by Nicolardot and Chatelot (*ibid.*, 25. p. 4) and on statements published in the Bull. Usines de Guerre as to the use of alloys. Platinum should not be used in presence of caustic alkali, but resists acids better than any alloy (as the figures in the Bull. also prove), though alloys (PtAu, PdAu) may answer in special cases such as concentration of sulphuric acid. For alkali hydroxides silver vessels are best in laboratories. H. B.

552. *Constitution of Iron-Chromium Alloys.* **E. Jänecke.** (Zeits. Elektrochem. 23. pp. 49–55, Feb. 1, 1917.)—Renewed experiments to overcome the difficulties of avoiding contamination by carbon when working with specimens of at least 100 gm. in crystal furnaces. The furnace consists of a cylinder of dynamidon (alumina with a clay binder) packed inside with cryptol; the crucible of dynamidon stands inside a magnesia crucible on magnesia. Working in indifferent gases was not attempted because cryptol itself gives off gases. Curves are recorded by a Wanner pyrometer. References are made to Treitschke and Tammann [Abs. 165 (1908)] and to Monnartz (dissertation, Aachen, 1911). Curves taken for six alloys between the limits 10 Fe : 10 Cr and 90 Fe : 10 Cr, show that the system Fe-Cr consists of a single eutectic able to form mixed crystals with either component. This eutectic contains 75 % Cr and melts at 1320°. All the alloys are tough, only those with more than 80 %

Cr can be broken on the anvil; they are easily polished and scratched by steel. Boiling nitric acid does not attack its alloys, but sulphuric acid does. The suggestion of a pseudo binary system, made by the previous workers mentioned, is criticised. H. B.

553. *Action of Hydrogen on Iron and its Compounds at Furnace Temperatures.* **F. Schmitz.** (Stahl. u. Eisen, 39. pp. 373–381, April 10, and 406–413, April 17, 1919.)—The dissociation of the iron oxides and compounds in the furnace is opposed by the atmospheric pressure, but it would be facilitated by the reducing action of hydrogen. When hydrogen is passed over (or blown through) molten iron, the C, Si, S, P, O, As are converted into hydrides which dissociate; the liberated H can reduce SiO_2 even at 700° to silicon hydride. Iron salts are decomposed into acid and metal. When iron is glowed in a gaseous hydride, the hydrogen liberated diffuses into the iron, while the non-metal combines with the iron until equilibrium is set up at certain temperatures and pressures, when neither cementation or tempering occur. Heated in pure oxygen compounds of iron and fused iron are oxidised to be decomposed at higher temperatures into lower oxides and gaseous metalloid oxide. A malleable iron can be obtained from solid pig by means of H and O as well as from liquid iron. Both C and Si diffuse into solid iron at high temperatures without first being converted into gaseous compounds. Nitrogen has no action on the non-metals contained in iron, solid or liquid. The carbon percentage is supposed to decrease when the iron is heated in nitrogen; this decrease becomes more and more imperceptible as all traces of oxygen are excluded. The experiments made in tubular electric furnaces lined with unglazed porcelain are not promising technically, since working with hydrogen at 1100° C. would be expensive and dangerous. H. B.

554. *Amalgams.* I. *Colloidal Gold Amalgam.* **C. Paal** and **H. Steyer.** (Kolloid Zeits. 23. pp. 145–148, 1918.)—Hydrosols of gold amalgam can be prepared by keeping gold ore in contact with mercury, or by shaking the two, by mixing the two hydrosols, or by precipitating the two metals, *e.g.*, by reducing an alkaline solution of the two chlorides by means of hydrazine in the presence of the sodium salts of protalbic and lysalbic acids. Two hydrosols, apparently Au_3Hg_2 and Au_2Hg_3, were obtained; evaporated to dryness they gave black or greenish black masses, redissoluble in water; in a hydrogen atmosphere they kept for months, yet they turned brownish, probably because air had gained access. II. (*Ibid.* 25. pp. 21–26, July, 1919.)—Keeping the constituents at rest during the sol preparation in sealed vessels, the authors obtained a sol of bronze-tint, of composition $AuHg_{0\cdot34}$, and a gel $AuHg_{0\cdot9}$. Other colour changes and peculiarities are mentioned. H. B.

555. *Theory of the Carbon Gasification Process.* **Wa. Ostwald.** (Chemiker Zeit. 43. pp. 229–231, April 29, 1919.)—When carbon is gasified on the grate or by the aid of steam in a producer, eight reactions may take place which may be summed up in three equations: (1) $C + O_2 = CO_2 + 97\cdot6$ cals.; (2) $C + 2H_2O = CO_2 + 2H - 18\cdot8$; (3) $C + CO_2 = 2CO - 38\cdot8$. When these reactions take place in the proportions a, b, c, the complete process is: $(a + b + c)\,C + aO_2 + 2bH_2O = (a + b - c)\,CO_2 + 2bH_2 + 2cCO + 97\cdot6a - 18\cdot8b - 38\cdot8c$. The presence of CH_4

and of N is disregarded. Only two of the three quantities a, b, c, are independent variables. They are determined by analyses and the results are plotted by the triangular coordinates of Gibbs. The triangle is divided into regions of combustion and gasification, and of regeneration. The author shows how isothermals and isocalorics are diagrammatically represented, and how the chemist may determine the thermochemical and volumetric characteristics of combustion under varying working conditions, the amount of coal consumed, the heating value of the gas produced, etc. H. B.

556. *The Rutherford-Bohr Atom in Organic Chemistry.* **E. H. Buchner.** (Chem. Weekblad. 16. pp. 521–527, April 19, 1919.)—Methane has a symmetrical tetrahedral structure. When carbon atoms are linked by a double bond, the four electrons have a larger orbit than the two electrons of single bonds, and the carbon atoms are further apart. Geometrical isomerism can be explained. The considerations are in accord with Kekulé's benzene hexagon in a plane, with alternating single and double bonds; some so far unknown possible isomers may be too similar to one another.

A. E. Lacomblé (*ibid.*, 16. pp. 832–834, June 14, 1919.)—The development of Buchner's views offers difficulties. Two electrons revolving in a plane at right angles to the line joining the nuclei of two carbon atoms in single bond would set up also an electromagnetic field which might be positive or negative. There should hence be several isomeric methanes, giving rise, if not symmetrical, to unknown enantiomorphous derivatives. In chain compounds positive and negative carbons should alternate, and a closed ring would only be possible hence with even numbers of carbon atoms. The X-ray diagram of diamond would be influenced by some of these considerations. H. B.

557. *Physico-Chemical Revision of the Atomic Weight of Bromine. Corrections of the Atomic Weight of Silver.* **P. A. Guye.** (J. Chim. Phys. 17. pp. 171–186, March 31, 1919.)—Referring to the researches of Moles and of Reiman on the discrepancy between the laws of Avogadro and of Mariotte and to his own papers [Abs. 1107 (1919)], the author concludes that the normal litre of hydrogen bromide weighs 3·64423 gm.; at pressures of $\frac{2}{3}$ and $\frac{1}{3}$ atmo. the weights are 2·42197 and 1·20729 gm. These figures would yield Br = 79·920. If Ag = 107·88 or 107·876, Br would be 79·916 or 79·913. A discussion of the most recent researches on Cl, Br, I, suggests that the atomic weight of silver should be lowered to 107·867. H. B.

558. *Determination of Molecular and Atomic Weights from Gas Density and Critical Constants.* **J. J. van Laar.** (J. Chim. Phys. 17. pp. 266–328, June 30, 1919.)—Referring to the purely physical methods of Guye, Leduc and others, the author remarks that, in order to correct for deviations from Mariotte's law, we should exactly know the value of the coefficients in $B = RTb - a$. In many cases we do not know B_0 exactly; the critical data gives us a_c and b_c, but we cannot calculate B_0 from the uncorrected values. When the critical temperature is below 300° abs. B_0 is very small, however. Relying mainly upon the recent work done in Leiden, the author develops formulæ for the calculation of B and B_0 in the case of H (also combined), He, A, Ne, N, O, CO_2. The discussion

deals particularly with abnormal, associated substances, for which the simple formula, often applicable, has to be replaced by a complicated formula. Saturated vapours of water, mercury, ammonia, are not associated at low temperatures, but are associated near the critical point (Hg completely). The high temperature favours dissociation, but the small volume favours association. N_2, O_2, PH_3, HF, HCl, HBr are also associated near the critical point. Calculations verifying the formulæ are made for a great number of elementary and compound gases. The atomic weights finally deduced for C, N, Br, S, H, He (calculated to 3 decimals) only He being an integer are in close agreement with accepted values. H. B.

559. *Thallium-Tin Alloys.* **P. Fuchs.** (Zeits. anorg. Chem. 107. pp. 308–312, July 29, 1919).—The equilibrium was studied by Kurnakoff and Puschin (*ibid.*, 1902) and by Bornemann (1912). The eutectic horizontal covers the range 0 to 73 % thallium ; there is a eutectic point at 166° with 30 % Tl, and the cooling curve shows a second arrest at 144·5°, indicating the transition point of Tl, which is lowered by the presence of Sn from 231°. H. B.

560. *Ternary Alloys of Aluminium with Magnesium and Copper.* **R. Vogel.** (Zeits. anorg. Chem. 107. pp. 265–307, July 29, 1919.)—That Mg and Cu make Al harder and mechanically stronger was observed by Schirrmeister (Ferrum, p. 26, Nov., 1916) ; Wilm (Metallurgie 8. p. 225) found that these alloys, cold worked and then reheated, became stronger in the course of hours and days. The author makes a thermal and microscopical study of the binary and ternary alloys, and gives also three-dimensional diagrams. The alloy Al_3Mg_4 is brittle, and the Mg contents should not exceed 6 %. The ternary alloys contain : ternary mixed crystals of the three elements, ternary mixed crystals containing Al_2Cu, the ternary compound Al_6Mg_4Cu, and binary mixed crystals of AlMg. These constituents can be distinguished by etching with nitric acid. The binary alloys of Al with Mg and with Cu show secondary arrest points, which the author ascribes to an allotropic change of Al connected with foreign constituents, but not due to the impurities (Si, Fe) in the Al ; a similar arrest point was observed by Gwyer in Al containing Ni and Co. This modification would not explain the peculiar increase in the strength of the cold Al-alloys after heating to 500° C. Binary metal compounds are frequent ; ternary compounds are rare, and occur only when there is inclination to combination in both the systems. The only real ternary alloys known are $NaKHg_2$ and NaCdHg. These melt without decomposition, which other ternary compounds like Al_6Mg_4Cu decompose into a liquid and a solid phase on melting or form these phases in cooling. H. B.

561. *Physical Nature of Valency.* **W. Kossel.** (Naturwiss. 7. pp. 339–345, May 9, and pp. 360–366, May 16, 1919. Chem. Zentrbl. iii. pp. 83–86, 1919.)—The paper deals with the fundamental problems of atomic constitution and combinations and hardly admits of abstracting. The constant valency of carbon and its want of polarity, previously regarded as typical and most simple, are in reality exceptional. In general we have to distinguish between heteropolar valency manifestations or linkings (the more common case) and homopolar linkings (molecules of

elementary gases). There are gradations in the two classes, and the want of character in carbon is practically unique and makes carbon unsuitable for valency studies. On the theory of electrons we need no longer regard electric forces as proceeding from the atoms as a whole. The bricks of the atoms exercise attractive forces on one another and cause unions of atoms or the formation of connecting bridges between them, without leaving the atom or necessitating its electric discharge. When components have passed from one atom to the other, and the atom as a whole has been discharged, the atom appears to be polar; there is a gradual transition between the two types of union. Passing to the atom models of Bohr, Stark, Thomson, and Rutherford, the author shows that electrostatic models had to be replaced by dynamic planetary models, and that the definity of spectrum lines in the latter was only explicable by accepting the quantum relation. The valency of heteropolar compounds may be explained on the electrostatic theory. The union of atoms occurs in two stages; an exchange of electrons is followed by the union of the ions. The 19 electrons of K are reduced to 18, the 17 electrons of chlorine are increased to 18, when the atoms are ionised. Inactive argon has 18 electrons in a most stable condition. For the elements of the type of inert gases the arrangement of the electrons is decisive for the repulsive forces which come into play at the mutual approach of the atoms, *i.e.*, for the impenetrability of the surface of the atom. The variability of the linkage is to be ascribed to the variability (the variabilities being subject to laws) of the nucleus charge which, together with the unchanged number of electrons, imparts to the atom a variable total charge. The properties of these simple model atoms, with central charges within impenetrable spheres, can be calculated. Though the atoms, owing to the integral increase in the total charge, unite in integral proportions, the nature of the model does not suggest any forces acting in any spacially-fixed directions of structural formulæ. The combining power of some compounds (Werner's complexes) cannot be classed with definite valencies. To form a neutral molecule the + and − charges must be equal. Nothing prevents, however, two neutral molecules from combining by the aid of the attractive forces of their own non-coinciding charges of both signs ($NH_3 . HCl = NH_4Cl$). On the other hand, the intensity of the charge, *i.e.*, the valency number, implies something novel which former valency theories could not take into consideration, particularly the force which one atom exerts on another and the work necessary to separate them. This work defines the frequency of separations, *i.e.*, the degree of dissociation of a compound; hence the capability of a compound to form ions is dependent upon the valency of the atoms concerned. Elements of high charges and valencies and of small volume (gold has both these properties) are particularly adapted to function as nuclei of complex compounds. Another aspect of these relations is explained with respect to the hydrogen compounds. As we proceed from the negative side of the periodic table in the hydrides from F to Cl . . . O and N, the acid character disappears more and more, and is finally reversed, when the hydrogen is more firmly bound by the higher nuclear charge. Hydrogen is (sixth group) less firmly held as the atomic volume of the second element increases; every atom should detach hydrogen from electrostatically weaker atoms. The author further refers to the multiple oxides of some elements and to their decomposition, some of which can be calculated when we make definite assumptions as to the atomic radius. For the complete representation

of valency we must, however, consider both the electrostatic and electromagnetic forces, and with the latter a quantum of action. H. B.

562. *Recrystallisation in Metals.* **G. Tammann.** (Ges. Wiss. Göttingen, Nachr. pp. 1–11, Jan. 22, 1918. Chem. Zentrbl. 1919, i. pp. 321–322.)—The cold-working of a casting develops in the metal planes in which the crystallites can glide. A fluid structure affecting the properties, especially the elasticity, is thus attained. Reheating restores the structure and properties and favours recrystallisation, which proceeds in steps when the temperature is raised in steps. This recrystallisation may be explained on the following lines. Two crystals in contact with one another can only be in equilibrium when the two space-lattices either form a single lattice, or when the plane of contact is a twin plane. If either of these conditions be not fulfilled, new planes of orientation are formed, *i.e.*, recrystallisation commences as soon as the temperature is sufficiently raised to admit of position changes. As the conditions will rarely be fulfilled, recrystallisation will usually take place. Twin formation indicates that the contact of two crystals in a common plane of symmetry does nor disturb the equilibrium; the plane is not formed by the accidental meeting of two growing crystals, but is due to the growth of each. In the case of tin, recrystallisation begins after half an hour's heating at 45°, but the new particles are still small at 150°. With zinc large crystals appear at 75°; their size decreases as the temperature is raised to 250°, and increases again on further heating to 350°; the particles have minimum size between 150° and 300°. Aluminium has a similar minimum between 300° and 500°. The author also shows with respect to rolled copper and tin, iron, etc., how the size of the particles depends upon the degree of previous deformation. H. B.

563. *Chemical Effects on Mechanical Work on Metals and their Mixed Crystals.* **G. Tammann.** (Ges. Wiss. Göttingen, Nachr. pp. 351–361, Jan. 24, 1918. Chem. Zentrbl. iii. pp. 90–91, 1919.)—Cold work increases the energy content of a metal, because the formation of gliding planes and the translation of particles lead to a decomposition and an increase in potential energy, and further because processes take place within the atoms leading to a similar increase. A cold-worked metal is less noble in the hard than in the soft condition. Since, however, surface layers are alone affected, a superficially hardened piece, still soft in the interior, may behave less nobly than a thoroughly hardened piece. This is confirmed by experiments on silver wire and also on bismuth, which was supposed to behave exceptionally. The increased rate of solution of cold-worked iron is ascribed to the formation of twin lamellæ. Mechanical working of alloys of gold with copper and silver alters the limits of chemical attack set by the respective concentrations. Rolled and hammered Au-Ag alloys are chemically more active than the soft alloys and remain active when they contain more gold than ordinary chemically active alloys. Polished metals behave like metals converted into thin foils. That work so much alters the range of chemical activity is ascribed to an alteration in the properties of the gold particles which, once displaced, are held less firmly in the lattice than before. H. B.

564. *Isomeric Alloys (from Liquid and Solid Solutions).* **G. Tammann.** (Ges. Wiss. Göttingen, Nachr. pp. 332–350, Dec. 20, 1918.

Chem. Zentrbl. iii. pp. 89–90, 1919.)—When two metals separate simultaneously at a temperature, at which diffusion is not possible in mixed crystals, the distribution of the atoms cannot be normal. This condition arises in precipitation from liquid (not solid) solutions. Binary metallic mixtures are, *e.g.*, formed in galvanic couples, in the electrolysis of mixed solutions, in precipitation of one metal upon the others, etc., and their analogy to alloys from solid solutions has been little studied. One of the factors is the rate of diffusion of the nascent metal. When a galvanic couple, immersed in a solution of the less noble metal, is short-circuited, kations of the latter metal are deposited on the former. When diffusion is negligible, the original potential is rapidly regained after opening the circuit; with rapid diffusion the recovery is more gradual. Diffusion can be detected with the aid of an electrometer. By the electrolysis of mixed solutions of the sulphates of Cu and Cd, deposits have been obtained, the potentials of which towards Cd vary between the values 0 and that of Cu. Alloys from the molten metals behave quite differently. Chemical affinity is another factor. The compounds Cu_3Cd_2, $CuCd_3$, Cu_3Sn can be obtained both by deposition and fusion; the compounds Cu-Zn, Ag-Zn, Ag-Cd differ in their proportions, when prepared by the two methods. Even in cases in which the two metals form continuous series of mixed crystals (Cu-Au, Fe-Pt), the precipitate is rich in the less noble metal. That the two kinds of alloys in these cases are not identical is shown for Cu_3-Sn, Au-Ag, Zn-Cu. H. B.

565. *Atomic Structures of Non-Metallic Mixed Crystals.* **G. Tammann** and **K. W. Schmidt.** (Ges. Wiss. Göttingen, Nachr. pp. 296–318, Nov. 29, 1918. Chem. Zentrbl. i. pp. 782–784, 1919.)—The occurrence of definite reactions limit enables us to distinguish between normal and irregular distribution of the atoms in the absence of abnormal double refraction. When water acts on mixed crystals of AgCl-NaCl, the latter salt is completely extracted when the AgCl proportion sinks below 0·625, but not when it exceeds 0·75, just as boiling nitric acid does not extract Ag from Au-Ag when the Au exceeds a certain percentage [see Abs. 1431 to 1433 (1919)]. The behaviour of the salts is explained by the distribution of the Ag, Na, Cl atoms in the space-lattice. Diffusion in mixed salt crystals differs quantitatively from diffusion in metals; in the latter it is more rapid near the melting-point and is also observed at temperatures considerably below the melting-point. In compressed mixtures of coloured and colourless salts (powdered) the rate of diffusion can be watched by the colour line; with electrolytes the conductivity yields a means of observation. Examples of organic and inorganic salts are given. The laws of dilute solutions cannot be applied to the solubility and vapour tension isotherms of series of mixed crystals, since equilibrium is not reached within reasonable periods. Mixed crystals of the nitrates of Ag and Na were prepared by very slow cooling of the mixtures of the molten salts and by cooling solutions of the mixed salts in aqueous alcohol. The former mixed crystals gave up much more silver nitrate when treated with saturated solution of sodium nitrate than the latter. Other examples are discussed. H. B.

566. *Distribution of Two kinds of Atoms in the Frankenheim-Bravais Space Lattice.* **G. Tammann.** (Ges. Wiss. Göttingen, Nachr. pp. 190–234, July 26, 1918. Chem. Zentrbl. i. pp. 781–782, 1919.)—The

crystalline form of well-defined mixed crystals does not differ from that of their components. In similar directions the properties of a mixed crystal are generally as equivalent to one another as in unmixed crystals. The occurrence of double refraction in mixed crystals of the regular system proves, however, that there are exceptions to this rule. That is because the postulate of equivalent directions does not definitely settle the distribution of the atoms; a most intimate admixture is also required, such as occurs at the temperature of rapid diffusion. These requirements signify that in "normal distribution," accumulations of similar atoms do not occur in the perpendiculars of the lattice, and that the number of perpendiculars of a group is a minimum. When either symmetry or the intimate admixture is wanting, the distribution is "abnormal." The normal state is the more stable, because in it changes produced by diffusion can only be transitory. The three regular types of space-lattices are those of Frankenheim-Bravais with cube or 8-point lattice (atoms at the 8 corners), the 9-point lattice (one more in the centre of the cube), the 14-point lattice (atoms in the centres of the faces). The normal distribution in these types can be determined in two ways which are discussed. The limited solubility of hydrogen in palladium exemplifies the penetration of the lattice (14-point) by an agent. The series of mixed crystals of gold with Cu and Ag do not indicate penetration of the mixed crystals. The atomistic constitution is closely connected with the different action limits. When copper is or is not dissolved out of mixed crystals it is assumed that the different reagents require differing numbers of Cu atoms for their action which are found assembled only in differing directions. H. B.

567. *Solubility of Hydrogen in Palladium Mixed Crystals.* **G. Tammann.** (Ges. Wiss. Göttingen, Nachr. pp. 72–78, June 17, 1918. Chem. Zentrbl. i. p. 338, 1919.)—Analogous to the limits of action of reagents on mixed crystals of gold with Ag and Cu we should expect a limit to the solubility of hydrogen in palladium, and this limit is found to exist in that temperature range, within which a change of position of the two atoms in the mixed crystals is no longer perceptible. This limit is found to be near $\frac{1}{2}$ mol. Pd. The hydrogen atom can apparently only enter and oscillate at lattice axes which are parallel to the diagonals of the cube, these being occupied by palladium atoms. H. B.

568. *High-Temperature Researches.* XII. *Measurement of Vapour Tension at High Temperature. Solubility of Carbon in Metals.* **O. Ruff** and **B. Bergdahl.** (Zeits. anorg. Chem. 106, pp. 76–94, May 9, 1919.)—The determination of vapour tensions at high temperatures is only possible when the fused substance bubbles visibly (Barus and Greenwood), or when the container is gas-tight, so that all gas passing off can be measured (Wartenberg). Neither method is available for some carbides and oxides and other substances which evaporate without fusing. The author's method is a development of that of Fichter and Oesterheld (Zeits. Elektrochem. 1915, p. 50). He plots the loss of weight from the specimen against gradually rising temperature. That loss curve is first logarithmic, and becomes irregular at the commencement of boiling and then linear, though the demarcation is difficult. About 0·5 gr. of substance is heated in a very small crucible of quartz or graphite, which is suspended from a spring balance within an electric furnace

charged with indifferent gases at various pressures. In this way the following boiling-points were determined: Mercury 357°, cadmium 785°, zinc 930°, arsenic 568°, antimony 1330°, bismuth 1490°, lead 1555°, tin 2270°, copper 2305°, silver 1950°, gold 2600°. The values for Hg, Zn, Cd agree with other determinations; in other cases the agreement is less satisfactory, and the new method seems to be best adapted for observations near the boiling-point.

In carbon crucibles the metals take up carbon. The amount of carbon dissolved is, however, generally too small to affect the boiling-point; the highest solubilities of carbon were observed in lead (0·094 % at 1555° and 0·024 % at 1170°) and antimony (0·094 % at 1327° and 0·033 at 1055°). Hg, Cd, Zn, As, Sn, Au dissolve only traces of carbon, Bi, Cu, Ag, a little more. These solubility estimates are based upon the amount of graphitic carbon residue left after boiling. H. B.

569. *Meteoric Nickel-Iron and the Polymorphism of Carbon-Iron.* **G. Tammann.** (Ges. Wiss. Göttingen, Nachr. pp. 258–266, Nov. 18, 1918. Chem. Zentrbl. i. pp. 806–807, 1919.)—Whilst Osmond and Cartaud [Abs. 425 (1904)] regarded taenite as a phase of kamacite, the author points to the reaction-limits of chemical agents in mixed crystals and does not regard two portions of a conglomerate, differing in properties, as distinct phases. Moreover, taenite need not itself be homogeneous. The meteoric structure can be explained on the basis of the equilibrium diagram of nickel steel. The distribution of the atoms of the two metals in kamacite (a mixed crystal) will not be normal and stable as in homogenised nickel steel, but rather unstable, as in mixed crystals with double refraction. The structure is probably that of the 14-point space-lattice. Unstable forms, which are probably to be regarded as space-lattice isomerides, also occur in carbon steels. H. B.

570. *Behaviour of Hydrogen towards Iridium.* **A. Gútbier, B[erta] Ottenstein,** and **G. L. Weise.** (Deutsch. Chem. Ges., Ber. 52 [B]. pp. 1366–1368, July 12, 1919.)—Studying the sorption of hydrogen by iridium as previously that by palladium [Abs. 1748 (1914)], the authors find that the hydrogen taken up by iridium is easily expelled again by a slight rise in temperature; the quantity absorbed is always small, the release never brisk, and the removal of the last traces very difficult. The iridium was a grey powder from Heraeus. The absorption curve is peculiar; iridium absorbs at − 30°, − 20°, 0°, + 20°, +49°, respectively 113, 115, 75, 140, 38 volumes of hydrogen, there being two maxima at about − 20° and + 20°. H. B.

571. *Behaviour of Hydrogen towards Spongy Platinum and Platinum Black.* **A. Gútbier** and **O. Maisch.** (Deutsch. Chem. Ges., Ber. 52 [B]. pp. 1368–1374, July 12, 1919.)—Platinum black is much more active towards hydrogen than spongy platinum. The black is prepared by mixing a boiling solution of chloroplatinic acid, neutralised with soda, with a boiling solution of sodium formate; the black is dried over sulphuric acid or phosphoric oxide. Long boiling and other conditions convert the black into a greyish modification (possibly intermediate between the black and spongy Pt) which the sodium formate reconverts again. Platinum black absorbs 160 vols. of H, the sponge only 1 vol.; above 0° the former absorption decreases, the latter increases as the

temperature rises; below 0°, at which the black has its maximum of absorptive power for H, the absorption decreases in both cases.
H. B.

572. *Uranium-Lead and Gravitation.* **A. Bull.** (Science, 50. pp. 69–70, July 18, 1919.)—The differences in the atomic weights of forms of Pb isolated from various minerals might be due to their different behaviour towards gravitation. The assumed constancy of weight to mass has only been verified for some substances, and need not hold generally. Theories of gravitation are still in a crude form. If gravitation and attraction were due to movements of electrons, a possible variation in that attraction might be ascribed to a gradual subsiding of the tension or agitation of the electrons caused by the splitting up of atoms during radio-active processes. On that view the atomic weight of uranium-lead should increase in the course of time as it changes into ordinary lead. H. B.

573. *The Amalgamated Copper Kathode in Electro-Analysis.* **J. Alemany.** (Anal. Fis. Quim., Madrid, 17. pp. 174–188, May, 1919.)—The difficulties of manipulating mercury kathodes in the deposition of metals are avoided by the use of the author's kathode of copper gauze and of a rotating anode of Pt or Fe. The gauze is first silvered in alkaline cyanide and then amalgamated by electrolysis in solution of mercurous nitrate; washing in water, alcohol, and ether follows. Details are given of the deposition, with high accuracy, of zinc and cadmium in sulphuric acid, neutral, alkaline, and ammoniacal solutions and in presence of nitrate; the bath is heated up to 45°. H. B.

574. *Magneto-Chemistry of Chromous and Oxychromic Salts.* **B. Cabrera** and **S. Piña.** (Anal. Fis. Quim., Madrid, 17. pp. 149–167, May, 1919.)—By the method of Quincke the authors measure the magnetic susceptibility of salt solutions. The chromous ion of sulphate and chloride solutions yielded the value 24 for the number of magnetons. In the complex ions of the violet and green modifications of oxychromic salts, $Cr_2O(SO_4)_2$ and Cr_2OCl_4, integral numbers of magnetons were not found.
H. B.

575. *Corrosion of Metals; the Rusting of Iron.* **F. Goudriaan.** (Chem. Weekblad, 16. pp. 1270–1285, Oct. 4, 1919.)—Reviewing the literature the author agrees that in pure water, free of air, the rusting of iron is purely electrolytic, and does not proceed beyond a concentration of Fe equal to $1{\cdot}2 \times 10^{-6}$ gm. mol. per litre. The presence of oxygen then gives rise to a new e.m.f.; carbon dioxide plays a secondary part, affecting the very variable composition of the rust, and its presence is not essential; hydrogen peroxide need not be formed (Traube). The corrosion is most rapid when both air and water are in direct contact with the metal. Electrolytes have a maximum concentration favouring corrosion, beyond which they may actually prevent corrosion; caustic soda and sodium carbonate stop corrosion already at low concentration. Ammonium salts corrode iron. For the influence of impurities and of other metals in contact with iron, definite figures cannot be given in most cases. H. B.